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OF

THE FIRST BIENNIAL CONFERENCE

OF

SUGARCANE RESEARCH WORKERS IN THE INDIAN UNION

COIMBATORE, JANUARY, 1951

PART II—3

PAPERS READ

IN THE

PLANT PROTECTION SECTION

Published by the Secretary, Indian Central Sugarcane Committee
3, Pusa Road, New Delhi
1951

Price Rs. 1/12/-

Only title printed at the Hind Union Press - New Delhi

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III. PLANT PROTECTION SECTION

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SUGARCANE ENTOMOLOGY

E. 1—A NOTE ON EARTHING-UP AS A MEASURE OF CONTROL OF *Argyria Sticticraspis* HAMPSON : THE SUGARCANE STEM-BORER

Mohammad Qadiruddin Khan, Hyderabad—Dn.

There are three methods tried out for the control of sugarcane stem-borers in India on a field scale :—

(*i*) Liberation of *Trichogramma*, the egg parasite

(*ii*) Removal of dead-hearts and destruction of borers

and (*iii*) Earthing up in the earlier stages of crop growth.

(*i*) *Liberation of Trichogramma*—Results of experiments conducted at four centres, though encouraging in a few cases, have yet to be critically assessed as to their efficacy. Besides, as pointed out by Dr. Pruthi (*Vide* Proceedings of the 12th meeting of the Entomological *Ad-hoc* Committee of the I. C. S. C.) despite periodical releases of *Trichogramma* it had failed to establish itself, ...necessitating continued yearly releases of the parasite to attain control of stem-borers. Moreover, under the existing conditions there are not enough breeding centres to supply the parasites to all the cane growers in the country.

(*ii*) *Removal of dead-hearts and destruction of borers*—The Entomological Committee considers this method as impracticable. It is also comparatively more laborious.

(*iii*) *Earthing up*—Under these conditions, this method remains the only means for the control of stem-borers, which is being recommended to the cultivators.

Review of previous work—Subramaniam and Ramiah (1935) were the first to demonstrate that an early and light earthing up (by

spade or mould board plow) assisted firstly, in preventing the entry of borer larvae into the plants and secondly, stopping migration of all except the older instars to adjacent tillers. It is stated that no adverse effect on tillering was noticeable. No yield data seems to have been recorded.

Sethi (1940) reviewing the prevalence of this cultural practice in various cane growing states of the country has generally pointed out the efficacy of this method in reducing borer incidence. However, corresponding increase in yield, following reduction of borer activity has not been stated.

Gupta (1945) was the first to study in detail this method with special reference to its effect on tillering, cane formation, yield and other factors. He obtained increased yields in some cases, inspite of reduction in number of canes formed. This is explained as due to increased weight of individual canes in treated plots.

Work in Hyderabad—Earthing up trials were conducted on a randomized replicated basis for two years (1948-49 and 1949-50) in the Scheme for Research on Insect Pests of Sugarcane (financed by the Indian Central Sugarcane Committee) at Bodhan in the vicinity of the Nizam Sugar Factory in the Nizamsagar Project Area. Co. 419 was planted during January-February to be treated as *Eksali* (12 month's crop). As soon as germination was complete or on the appearance of dead-hearts, which ever was earlier, the first earthing was given. Two more earthings followed at fort-nightly intervals. Tri-weekly counts of dead-heart production revealed a gradual decline in the earthed-up plots as compared to control.

Discussion—The efficacy of light-earthing young cane crop in reducing dead-heart production by stem-borers first suggested by Subramaniam and Ramiah (1936) was experimentally demonstrated by Gupta (1945). The latter also proved the adverse effect of this operation on tiller-production resulting in lesser number of millable canes at harvest, as pointed out by Sethi (1940). However, higher yields were obtained in treated plots in some cases. This is ascribed to the "Slight increase in the average weight of individual cane sticks".

Two years experimental work in Hyderabad has showed that the yield was higher in untreated plots. This was in conformity with the pre-harvest data, wherein the earthed plots gave lesser number of millage canes at harvest. Also the average weight of individual canes from the two treatments show negligible differences (table No. 3 Columns 6 & 7), which is contrary to Gupta's findings.

The increased yield obtained in untreated plots in Hyderabad and the inconsistent yield data obtained at Muzaffarnagar shows that this method cannot be recommended on its present basis. But in view of its effectiveness in reducing borer incidence, it is

necessary to take up this work in representative centres and observations in greater detail made to establish the following points:—

(*i*) The extent to which the earthings individually and in combination at different intervals affect dead-heart production, borer mortality, tiller production, cane formation, individual weight of cane and yield.

(*ii*) The possibility of obtaining the best combination of earthings to be done at specified intervals which, while reducing borer activity, interfere least with cane formation and ultimately yield.

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E. 2—The Top Shoot Borer of Sugarcane in Bombay State and its Control by Mechanical Methods

P. V. Wagle, Ahmednagar

This pest of Sugarcane, the worst ever noticed, was first reported in Bombay State about ten years back. Since then it has spread practically over the whole of the important Sugarcane growing tracts of this State, affecting so far generally five to ten per cent of the plants. In bad cases of attack, the infection is found to be over 40 to 50 per cent. The first shock of the severity of this pest was received by the Belvandi Sugar Farm in Ahmednagar district in October 1949, when it was found that their whole estate of

about 600 acres was infested by it. A block of about 80 acres of *Adsali* or July planted cane showed about 40 per cent of the plants with the typical 'bunchy top' appearance, while the rest of the area had 10 to 15 per cent infection. The attack was found in young, as well as, old canes, but the former appeared more suceptible. Greater infection was also observed in sugarcane planted in June-July than in the other plantings.

The usual control measures, *viz.*, collection of egg masses, cutting and destruction of affected plants, attraction of moths by light traps, light earthing up of cane, were immediately adopted by the factory management. Chemical control by dusting with Gammexane D. 025 and spraying with Guesarol 550 were also tried, but the results were reported to be not quite satisfactory. It was, therefore, decided to systematically follow the mechanical methods only and to see how far the pest could be brought under control. The results so far have been found to be very encouraging. The details of the methods adopted are as follows :—

(1) *Collection of egg masses*—The collection of egg masses is made regularly every week before the caterpillars hatch out and is continued till the crop is 5 to 6 feet in height. Advantage is taken of the egg parasites found in nature by keeping the egg masses collected in a cage and allowing the parasites to escape in the field. The borer caterpillars hatching out of unparasitised eggs are collected in a tray of water kept below the cage.

(2) *Collection of affected plants*—The affected plants show the typical symptoms of attack such as 'dead heart', leaves with shot holes, reduction in size and browning of one border of the top leaf, channels in the midribs of some of the top leaves showing the passage of the borer and sprouting of the side shoots of the plants producing what are commonly known as 'bunchy tops.' Of these, the midrib markings are the earliest visible symptoms and the sprouting of the shoots is the last. The female labourers of the factory have been specially trained for this work and they are able to pick out the young affected plants even in the very initial stages of attack. The cut plants with the borers inside are collected and fed to cattle, or destroyed either by burning or by burying them in a pit. Regular rounds are taken over the whole estate at intervals varying from a week to a fortnight. Some times a fairly large number of the caterpillars inside is found parasitised. Such parasitised caterpillars are then collected and kept in a cage and the parasites on emergence are released in the field. After four to five months, when the crop grows up 3½ to 4 feet in height, the cutting operations are stopped as further cutting is very difficult and likely to lead to bad results, although the infection continues right till harvest time.

(3) *Attraction of moths to light traps*—Moths were attracted to Petromax lights hung over the crop at night in the first two plant—

ings, but this was subsequently stopped, as the number of moths caught was not quite satisfactory, the daily catch being only 10 to 12 moths per light.

(4) *Light earthing up of cane*—This is practised in the early stages of the crop as it blocks up the exit holes of the moths and is, therefore, useful to some extent. It was, however, found to be of no use when the crop was grown up.

It has been seen that by following these mechanical methods there is a substantial fall in the borer infection from 20. 9 per cent to 1·4 percent during the first four or five months of the life of the crop, when it is very susceptible to the attack. The first three crops will be shortly harvested and it is proposed to record the further infection that has taken place in the crop up to harvest time. In the absence of any better methods, it is proposed to follow these duringthe next two or three years and see how far it would be possible to further reduce the borer trouble. It has been observed that the cutting of the affected plants in the early stages induces tillering and it appears from the stand of the crop so far that the yield will not be adversely affected.

E. 3.—Loss Due to Internodal Borers

C. Rama Chandrachari, Anakapalli

Introduction : Borers on internodes of sugarcane are widely prevalent in this State. Their appearance in serious form was noted in Vizagapatam district during 1947-48 and in Trichinopoly district during the current season, when over 75 to 90% of the canes were recorded to be infested. The extent of their appearance and loss in yield of cane and sugar in the different important tracts of the State have not been fully surveyed. Investigations were undertaken at Anakapalli to evaluate the loss in yield and quality of juice due to internodal borers.

The Internodal Borers—At Nellikuppam in South Arcot District, *Argyria sticticraspis* was recorded as essentially an early shoot borer, while *Diatroea venosata* as internode borer. Population counts on the incidence of the borer reveal that *Argyria* predominantly appears in the fields from planting time upto August, whereas *Diatroea* appears in the field from July onwards. Studies on the last three seasons at Anakapalli showed that *Argyria* only appears as early shoot borer, from planting time while *Diatroea* does not appear in the field at this stage of the crop. From July-August onwards, when the canes form internodes, *Argyria* continues as internode borer also. *Diatroea* also appears in the field from July-August. But a close examination of

the bored internodes reveal that *Argyria* is the dominant internode borer in this tract.

Under Anakapalli conditions both *Argyria sticticraspis* and *Diatroea venosata* are of importance as internode borers.

Loss in yield—Loss in yield due to internodal borers is conditioned by many factors such as (a) percentage of canes infested, (b) percentage of internodes infested in a cane, (c) length of tunnel by each borer in the infested canes and (d) the stage of crop growth when the infestation occured.

The percentage of canes infested by internode borers was reccorded to be as high as 75% at Anakapalli and Bobbili and as much as 90% at Pugalur in Trichinopoly district. The average number of infested internodes in a cane is noted to be 2 out of the total 21 internodes in all infested cane. Also the average length of the tunnel in the bored internodes is not more than three inches, though in some cases the tunnel was as long as 2 feet running through 6 to 8 internodes. In a rare instance the borer infestation was seen in 12 out of 22 internodes and the total length of lesion in this cane was 2'—6", when the total length of the cane itself was only 5 feet. This last example brings up the effect of borer on the length and girth of internodes. (Average length of internodes 3.2" and average girth 0.73" as compared to average length of 4.7" and girth 1.15" in a healthy cane). The weight of the cane was 0·99 lb. against the average weight of 3 lb. 5 ozs. of a healthy cane.

The borer infested canes were sorted out at random and the number of internodes, length and weight of millable canes were recorded.

During the examination of infested canes it was observed that the effect of borer on elongation of internodes was more pronounced locally on the infested internode and 3 to 4 succeeding internodes. Thereafter the elongation of internodes appears normal.

At harvest time 4 series of estimations were made on Co.419 and Co. 475 to evaluate the percentage of loss in weight due to internodal borers. The data furnished in the following table reveal that a maximum loss of 5.60% in Co. 419 and 6.43% in Co.475 may occur and between the two varieties Co.475 was more susceptible. The greater susceptibility of Co. 475 may be attributed to its softness. This is indicated by observation made in this laboratory in which under laboratory conditions the larvae could not attack the internodes through rind in mature cane bits, while they bored through the rind in the case of soft immature canes. Therefore, the borers naturally prefer soft canes or soft portions of a variety.

Juice quality — The infested internodes record lower extraction, sucrose and purity, but the extent of loss depends on the extent of the internodes infested.

Loss in sugar also appears to be localised in the region of infestation, because no serious loss of sugar could be detected when the whole canes were considered. During the current season, the incidence of internode borers was recorded to be as high as 90 per cent in the Pugalur factory area.

Conclusion—Under Anakapalli conditions *Argyria sticticraspis* occurs not only as early shoot borer, but also as a dominant internode borer. The loss due to internode borers is more in weight of cane than in quality of juice.

E. 4—Occurrence of Certain Minor Pests on Sugarcane at Coimbatore

G. Narasimha Rao, Coimbatore

The paper gives a brief account of two minor pests of sugarcane one of which viz., *Schizotetranychus* (Tetranychidmite) has been noticed for the first time on sugarcane at this Station. The second is the Coccid, *Targionia glomerata* which is noticed to be seriously affecting certain varieties of sugarcane at Coimbatore. Till last year, it was not a serious pest at this Station. The incidence of these two pests on the forms and species of *Saccharum* are detailed below :—

I. Schizotetranychus andropogoni Hirst*

This pest was observed for the first time last year at the Thick Cane Area and at Vedapatti. It has not so far been noticed at the main area, though the grass *Dicanthium annulatum* (*Andropogon annulatus*) has been heavily infested both at the main area and Thick Cane Area.

This pest was first described by Hirst. (1926) A study of the adult tallies with the description recorded by Hirst. *viz.*,

"Hairs on body plain, not being feathered. Penis shaped rather like that of *Anychus latus* and also somewhat resembling that of *Paratetranychus ilicis* as figured by McGregor. Terminal finger of palpal tarsus moderately elongated, rather slender and bluntly pointed apically ; the two rod-like setae near the terminal finger are shorter than it ; dorsal finger very slender and slightly club-shaped. Claws of all the legs bifurcated.

Fingers and setae on trsus of palp very similar to those of the male sex. Claws of legs bifurcated as in the male.

Length of body of male (including head-plate) 0.24 mm ; length of penis (strongly chitinized part only) 14 u, of terminal finger of palpal tarsus of male 5 u, of dorsal finger of same 5 u.

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* Identified as ***Schizotetranyclus andropogoni*** Hirst by Dr. E. W. Baker of USDA

Host plant : *Andropogon annulatus* **(leaves) ; Coimbatore, India** (M. C. Cherian).

Cherian (1931) has reported the occurrence of this mite at Coimbatore and Aduthurai in South India. He mentions *Andropogon annulatus* as the host plant at Coimbatore. In his paper on "Mite (*Acarina*) pests of crops in South India and methods for their control" Cherian (1938) makes no mention of this species as occuring on sugarcane or any other commercial crop. Hence this seems to be the first report of its occurence on sugarcane in South India. Rahman and Sapra (1940) while dealing with the biology of *Paratetranychus indicus* Hirst state that sugarcane is also attacked by another species of the genus *Tetranychus* which does not produce any red colour. The reference is perhaps to *S. andropogoni*.

The incidence of the pest was first noticed during the month of May. With the onset of the South West monsoon during July the attack diminished evidently due to the washing off of the larvae and adults by the rains. In August again the incidence was found to be high.

The adults feed by sucking the plant sap with the stylets. The characteristic feature of the attack of a leaf by the pest is the presence of numerous whitish patches—the webs—on the underside of the leaf, both on the edges of the mid-rib and the general leaf surface. The individual patches do not coalesce and form one continuous patch as in the case of *Paratetranychus*, nor are reddish patches noticed. This enables the differenciation of the species from *Paratetranychus indicus*. When the web is removed, the leaf surface underneath has been noticed to have turned white due to loss of chlorophyle. In each web, not more than three or four individuals are noticed and all stages from larvae to adults are met with.

The interesting feature about the attack of the mite is the relative resistance of varieties to its attack. While the two forms of *Saccharum spontaneum*—Coimbatore and Burma at the two ends of the plot are heavily infested, the varieties in between them show varying degrees of infestation, from no attack to fairly heavy incidence. A microscopical investigation of the causes for such irregular incidence of attack showed that in all the varieties heavily infested, the lower surface of the leaf possesses bristles and stomatal grooves, the former enabling the easy spinning of the web and the latter affording safe resting place for the mite. The varieties like *Sclerostachya* and *Narenga* which are free from attack do not possess either the stomatal grooves or bristles. Khanna and Ramanathan (1947) have reported similar findings in the case of *Paratetranychus indicus* Hirst attacking sugarcane varieties in Bihar.

Rahman and Sapra (1940) report that soft leaved varieties of sugarcane were more susceptible to the attack of this mite (*Paratetranychus*). The reverse seem to be the case with this mite, as soft and

smoothed leaved varieties are comparatively less susceptible than hard andtough leaved ones.

The degree of infestation of the varieties at the Thick Cane area and Vedapatti is given below :—

Thick Cane Area

1. *S. spontaneum* (Glagha)—Heavy
2. *S. spontanenm* (Coimbatore)—Heavy
3. Co. 285—Heavy.
4. *Kassoer* } Free
5. *Narenga* } Free
6. *Scherostachya* } Free
7. *Vellai*—Light.
8. Co. 421—Light to medium
9. Co. 453—Medium
10. Poj. 2725—Light
11. Z. W. Cheribon—Medium heavy
12. Poj. 2961—Almost free

Vedapatti Area

1. *Erianthus fulvus*—Heavy
2. *Miscanthus nepalensis*—Heavy
3. *Dicannthium annulatum*—Heavy

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*II. Targionia (Aspidiotus) glomerata Green**

Green (1903) was the first to report of the occurrence of this Coccid insect on sugarcane in India on the species *Saccharum officinarum*. It was recorded as a pest of sugarcane gaining in importance. There seems to be no other record of this pest as occurring on sugarcane and does not seem to have attracted attention either due to its minor importance or due to its absence.

Very heavy infestation of this scale insect was noticed last year on two varieties *viz*. *S. spontaneum* Burma and Co. 745. The entire stem was covered with the scales, the stem presenting a blackish brown appearance Certain other varieties have also been noticed to be attacked, but the degree of infestation varies. In the same plot some varieties are comparatively free while others are heavily attacked.

The description recorded by the author tallies with that given by Green, *viz.*,

"Female puparia crowded and adhering together in such a manner that it is difficult to isolate a single individual. Form irregularly circular, slightly convex. Colour smoky brown or grayish black. Pellicles large, shining, black ; normally concealed beneath a covering of the fuliginous secretion. Ventral scale whitish stout Entire. Diameter 2.50 m. m.

Male puparium similar to that of female, but much smaller and more oval. Long diameter 1. mm.

Adult female of normal oval form ; cephalothorax evenly rounded, spiracles without parastigmatic glands surrounded by a concentrically wrinkled area. Pygidium deltoid. Lobes six, prominent, well defined with evenly rounded edges ; the thickened basis extending inwards. Four clavi-form thickened processes (Paraphyses) extending inwards between the lobes, two on each side, Margin beyond the lobes strongly but irregularly serrate. Pectinate squames between the lobes. No circum-genital glands A strong chitinous bar-interrupted in two ploces-extending across bass of pygidum. Genital aperture anterior to anal. Numerous oval pores, with thickned chitinious rims, on both dorsal and venteral surfaces, connected with long filiform ducts. Length 1.50 mm. to 1. 75 mm. Breadth 1.20 to 1.40 mm.

Adult male not observed. Habitat-Beneath the sheating bases of leaves of sugarcane.

Locolity-Coimbotore"

The insect attacks the cane only during the later stages of the crop viz , after five months. The larvae are blown by the wind and thus spread. One interesting feoture noticed is that the attack is

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* Identified as *Targionia glomerata* by Dr. Herold Morrison of USDA

considerably less in such of the varieties as are self trashing. This is explainable on the basis that in non-stripping varieties the larvae are able to deposit themselves in the space between the stem and the leaf sheath. Multiplication starts later and the insect spreads throughout the stem. In self stripping varieties the larvae do not have a hold and hence the considerably lower degree of incidence in such varieties.

Anatomical investigations undertaken to find out the mode of entry show that the insect protrudes its stylets into the stem through the stomata. A longitudical section revealed clearly the mode of entry and the presence of the stylet inside the stem. The tip of the stylet was in contact with a vascular bundle. It was felt that the number of stomata may be a determining factor in the resistance of varieties to this insect. Preliminary studies have indicated that there is relationship between the number of stomata and resistance or susceptibility of the varieties.

Details regarding the incidence of the pest in some of the varieties is given below :—

Variety	*Incidence*	*Self-trashing or not*	*Number of stomata per field*
Co. 745	Heavy	Non-self trashing	14
S. Spont Burma	Heavy	—do—	7
Co. 617	Heavy	—do—	9
Co. 285	Heavy	—do—	6
Co. 421	Medium	Moderately self trashing	3
G. 6300	Medium	Non-trashing	4
Co. 649	Medium	Moderately self trashing	4
Co. 408	Light	Self trashing	1.25
G 6299	Almost free	do.	1.0
Co. 443	Almost free	do.	1.0
B. 3013	Almost free	do.	1.0
Co. 442	Almost free	Fairly self-trashing	3
Co. 439	Almost free	Self trashing	1.0
Co. 720	Light	Fairly self trashing	2
Hotte Kabbu	Medium	Moderately trashing	3
Uba Marrot	Medium Heavy	Non-trashing	8.4
Co. 633	Medium	Moderately trashing	4.3

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Green, (1903) *Indian Museum Notes, Vol.* V. No. IV 1903

E. 5—Army Worm on Sugarcane

P. V. Wagle, Ahmednagar

There seems to be no record so far of any attack by 'Army Worm' on Sugarcane in any part of India. Noel Deerr, in his book 'Cane Sugar' has referred to several leaf eating caterpillars, the most notorious being the 'Army Worm', *Cirphis unipuncta* observed by Swezey in the Hawaiian islands. These are reported to appear suddenly and disappear as suddenly, the causes of the epidemics being obscure. Further, he has stated that in some cases, local conditions, such as floods, may have caused them to desert their usual feeding places.

Reports of a similar sudden attack by 'Army Worm' on Sugarcane grown in the beds of the rivers *Panchganga* and *Krishna* early in August 1950 were received from the Sugar factories at Kolhapur and Ugar in the Southern Maratha Country in Bombay State. The affected areas were submerged for three to four days in the flood waters of the rivers in the last week of July, following the torrential rains in the western ghats, where these rivers originate. After the floods subsided and the lands became accessible, signs of a severe attack of a leaf-eating caterpillar, feeding voraciously on the green leafy portion, leaving only the midribs of the leaves standing erect and throwing out masses of excreta were clearly visible in patches in the submerged areas. These affected patches were not spread all over, but were particularly located in such pockets that the sugarcane growing in those places served as an obstruction to the receding flood waters. The area affected by the pest was about 110 acres in both the sugar factory estates and almost an equal area belonging to cultivators. Out of these 30 to 40 acres were very severely affected. Similar trouble is also reported to have occurred in the year 1933, just after the rivers were in high floods.

The pest appears to be a *Cirphis* species (Specimens have been sent to the Head of the Division of Entomology, Indian Agricultural Research Institute, New Delhi for identification). The stout caterpillars blackish in colour with light greenish stripes on the body were found in large numbers, resting during daytime inside the dry leaves or the green leaf sheaths separating out from the cane and thus providing them with suitable shelter. They were nocturnal in their habits and came out and fed on the leaves at night. When disturbed, they curled up and dropped down to the ground and remained motionless. They moved from plant to plant in swarms in search of food. The pupation generally took place in the soil, but when there was standing water round about, the pupae were also found on the plant inside the leaf sheaths.

Inspection of the surrounding grassy areas showed the pest feeding on the grass locally known as *marvel* (*Dichanthium caricosum*)

and the brown pupae were found in large numbers in the soil below. From these observations, it appears that the pest was breeding on the grasses in the forest areas of the western ghats and that the egg masses were washed down with the flood waters of the streams. The sugarcane growing in the river bed and standing above the level of flood water might have served as an obstruction to the current, especially while receding and thus caused the deposition of the egg masses on the cane. The damage to the cane leaves was observed at such places about three weeks after the floods, by which time the caterpillars hatching out of the eggs had voraciously fed on the leaves. Although some moths emerged out of the pupae, there was no second brood of the pest.

The pest was controlled by the following methods :—

(1) Collection of the caterpillars and pupae found on the plants and destroying them by throwing them in a bucket with kerosenised water

(2) Removing the cane trash harbouring the pest during day-time and burning the same

(3) Flooding of the cane area for destroying the pupae in the soil

(4) Clearing of the surrounding grass and stirring of the soil to expose the pupae, and

(5) Spraying the affected and surrounding areas with Agrocide Wettable Powder.

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E. 6—Choroedocus Illustris Walk: A Potential Pest of Sugarcane

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I hereby report on an observation made on insect injury to the growing point of canes by the grass-hopper, *Choroedocus illustris* Walk at the Sugarcane Sub-Station, Karnal. It was noticed for the first time in November, 1942, and a large number of growing points in canes was completely damaged by gnawing from outside. The spindle showed the "dead heart" exactly similar to Top borer attack. The attack in every case was from outside. It was also found that the damage was not caused after a number of trials in differen- places in order to locate the growing point as there were no indica-tions of damage any where else on the shoot except at the exact location of the growing point.

The position of growing point in different varieties is different. For example in the *Mungo* group, the growing point is 13 inches below the highest transverse mark, in Burma form of *S. spontaneum* it is 7 inches below, in *Katha* and *Nargori* groups it is 6½ inches below, and in *Pansahi* group it is 5½ inches below the highest transverse mark. The grass hopper in the *Mungo* group gnaws exactly at the 13 inch level and in *Katha* and *Nargori* groups at 6½ inch level and so on, though it is very difficult for any one to locate the growing point of canes from outside.

Again in 1943, the attack was first noticed in July on fodder canes Co. 559, Co. 560 and , Co. 561 and subsequently on other cane varieties. The fodder canes posses three doses of *Sorghum helepense*, blood and resemble *Sorghum helepense*. Attention was concentrated on these varieties and after days of watching it was noticed that the damage was caused by a species of grass hopper *Choroedocus illustris* Walk. To confirm this, a few grass hoppers of this species were left in a big cage with cane shoots in pots. The grass hopper was seen moving on the shoot and after electing a particular point it began gnawing till it reached the growing point and ate that.

An analysis of its attack yielded interesting data. In the month of June, prior to the rains, *Sorghum helepense* was rare and a few grass hoppers attacked canes specially Sugarcane *Sorghum helepense* crosses. In July, after the rains, *Sorghum helepense* grew vigorously and the grass hopper shifted from the cane to the *Sorghum* and did the maximum damage. At the end of August *Sorghum helepense* flowered and hence the growing point was not available to the insect. At this part of the year the population of the grass hoppers was much. It shifted to the cane as an alternate host. Thousands of canes were damaged. In 1944, the damage was noticed even on medium and thick canes. Precautionary methods were taken by catching all the available insects and destroying them. The attack was less in 1945 and 1946.

It may be pertinently asked as to why such a damage by this insect is not being reported as a pest from other sugarcane farms and the chief interest of the foregoing observations seems to be in the probable answer to this question. Probably as we are evolving improved hybrid varieties of cane, the evolution of fresh pests of cane is also taking place side by side. Evidently the insects causing the peculiar damage reported herein are primarily the pest of the grasses used as parents of some of our cane varieties and probably this pest at present is in the process of following up the blood of its food plant to the cane varieties containing the same. Thus, the present observation may be a concrete case illustrating the process by which the other pests of sugarcane might have evolved. In case this process of reasoning is a correct interpretation of facts, then the practical significant of the present observation comes to be that we must be vigilant about the pests of the parents we use in breeding new varieties and thus, from the beginning avoid the

inheritance of susceptibilities to these potential pests which if inadvertently led to a taste of sugarcane, may become a serious menace not only to the variety of cane evolved with the pest but, to all varieties of sugarcane.

A strictly parallel and interesting case in this connection is that of *Aphis maidis*, which after the classical work of Brandes is now accepted as the insect vector which transmits mosaic. As is well known, *Aphis, maidis* is an insect which feeds commonly on maize, sorghum and various other grasses. In the intergeneric cross made at Coimbatore for the first time in 1929 it was found that though *Aphis maidis* had not so far been noticed to colonise freely on suagrcane at Coimbatore, certain of the sorghum hybrids, however, showed infestations and Co. 354 and Co. 515 hybrids between POJ. 2725 *Sorghum Durra* Stapf have proved susceptible to mosaic.

E. 7—A Resume of the Trials Conducted during 1941-44 with *Trichogramma evanescens minutum* Riley against the Stem borer *Argyria sticticraspis* Hmpsn. and Root Borer *Emmalocera depressella* Swinh, in the Uttar Pradesh

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Mass production and field trials with *Trichogramma* were in progress during 1941 at Muzaffarnagar when the Imperial Council of Agricultural Research sanctioned a scheme for similar studies to be taken up at several places in India. The *Trichogramma* colonisation work was then looked after by the staff employed under the scheme from April, 1942. Field releases were carried out in the same year at Meerut against the premonsoon attack of the stem borer, *Argyria sticticraspis* Hmpsn. and the root borer, *Emmalocera depressella* Swinh. and at Gorakhpur against the post-monsoon attack. The trials were again repeated in 1943 and 1944 at Muzaffarnagar. A resume of these trials from 1941 to 1944 is given in the following pages along with the factors which contributed towards the failure of *Trichogramma* in the control of stem and root borers in the Uttar Pradesh.

Field Trials 1941—A field trial on fully replicated basis was carried out from April to July, 1941 at Mansurpur Sugar Factory Farm, Muzaffarnagar. The released and control plots of Co 312 were contiguous with a buffer area of 24' all round the nett plots each of ⅑ acre. The treatments included the number of wasps to be released and the period from which the releases should commence. The wasps were released twice a week at the rate of 6000 and 12000 parasites per week, per acre, commencing from 16th April, 1st May and 16th May and were continued till the middle of July. Observations on the egg-

deposition and incidence of *A. sticticraspis* were collected from four 6′ × 6′ units (3 per cent row length) marked out at random in the nett plots and four in the buffer area surrounding it. The eggmasses deposited were counted, labelled and followed till they hatched out. During the period from the 16th April to 31st May, about 99,000 wasps were released in the treated plots. The stem borer was quite active and profuse egg laying was in progress, as was evident from the deposition of 3400 eggs in 72 units of 6′ × 6′, amounting to 54,400 eggs per acre. Inspite of the heavy density of host eggs, the *Trichogramma* wasps failed to establish themselves and not even one parasitised egg mass was ever noticed. During the period from the beginning of June to the middle of July, 126,000 wasps were released in 14 shifts, but no parasitisation was observed as the host population was considerably reduced due to 5″ rain in the 1st week of June. The failure of the parasite in May may be due to the high atmospheric temperature and low humidity. The highest maximum temperature recorded during May was of the order of 109°F to 111°F, while the lowest relative humidity observed during the corresponding period was 10 to 22 percent. The *Trichogramma* wasps prior to releases were always tested in the laboratory on *A. sticticraspis* eggs, where they parasitised all the eggs proved fully effective. The temperature in the laboratory was kept below 100°F by the use of *khus tatties*, sprinkled with water after every few hours.

1942—The *Trichogramma* colonisation experiment was conducted in the cultivators fields at Meerut during May, June and July, 1942, according to the instructions of the Imperial Entomologist, New Delhi. Six blocks of three acres each of Co. 312, selected for the purpose, were segregated from each other by a distance of 3 to 5 furlongs between them. *Trichogramma* releases were carried out at weekly intervals from the 20th May to 24th June in four out of the six blocks, the remaining two blocks were treated as control. The rate of release was 12,000 wasps per acre, per release. Observations were collected by examining one per cent of the total row length in each of the subplots before the commencement of the releases and also after each of the releases according to the method recommended by the Statistician, Indian Agricultural Research Institute, New Delhi. It was observed that the egg deposition by *A. sticticraspis* was maximum during the 3rd week of May prior to the commencement of releases, when 5200 eggs were deposited per acre in all the plots than at any other time during the course of the experiment. The eggs were marked out with red tape and removed at fortnightly intervals, but no trace of parasitisation was ever recorded. Among the various causes which might have contributed towards the failure of *Trichogamma*, the decrease in the density of the host population deserves particular consideration. During the period that the releases were in progress the egg deposition by *A. sticticraspis* was about 3000 eggs per acre in the treated plots. This number appears to be too low for the effectiveness of *Trichogramma* to be felt. Besides, the temperature was extremely high and the percentage relative humidity very low. The maximum tem-

perature was as high as 112.5°F and remained so for over a fortnight, while the lowest percentage humidity recorded during the corresponding period was of the order of 7 to 11 per cent. Under such high temperature and low humidity conditions, it became difficult in the laboratory to secure a high degree of parasitisation of the *Corcyra cephalonica* egg (The laboratory host of *Trichogramma*). Consequently the wasps utilised in the colonisation experiment had a prolonged refrigeration effect.

The post-monsoon releases were carried out at Kusmi farm, about eight miles from Gorakhpur. Six releases of *Trichogramma* wasps at the rate of 12,000 wasps per acre, per release, were made at weekly intervals from 20th October to 24th November,1942. The incidence of stem borer *Diatraea auricilia* Ddgn. and root borer was observed to be about two to four per cent before the releases were started. No fresh egg mass was ever noticed, either before or during the course of the experiment and, therefore, no tangible results on the effectiveness of *Trichogramma* could be gathered as the activity of the stem and root borers had ceased by the time the release trials were taken up.

1943—This time the trial was again carried out at Mansurpur Sugar Factory Farms, Muzaffarnagar. The three treatments *viz*, control, 1st set, and 1st plus 2nd set of releases were laid out in two replications in six well segregated blocks of 3 acres each of Co. 312.

The releases were made in two shifts beginning from 22nd April and 9th June. Six weekly releases were made under the 1st set finishing on the 28th May, and twelve weekly releases were made under the 1st plus the 2nd set which finished on 19th July. The number of parasites released each time was 8000 per acre. The method of recording the egg and borer population was the same as adopted in the preceding year.

The oviposition by the stem borer *A. sticticraspis* was at its maximum during the third and fourth week of May when 9230, 6730 and 3600 eggs per acre were recorded respectively in the control, 1st set and 1st plus the 2nd set of the treated plots. At the peak of egg deposition, a parasitisation of 7.4 per cent was observed in the1st set of released plots on the 15th May. It was again recorded during the 1st week of June when 5.3 per cent and 2.3 per cent of thee ggs deposited in the 1st set and 1st set plus the 2nd set of released plots were parasitised, respectively. A partially parasitised egg mass was recorded from the 1st set plus the 2nd set of released plots on 29th June. the maximum number of root borer eggs were observed during the latter part of July of which very few were parasitised.

The activity of *Trichogramma* wasps, however insignificant in effect, was observed at a period when the maximum temperature was extremely high and the relative humidity very low.

The occurrence of *Trichogramma* under unfavourable climatic conditions and contrary to the observations made in the past, surprising as it appears, gives the impression that the parasitisation has been more of a sporadic nature than as a result of regular colonisation. It is proved by the low parasitisation of 2.3 per cent to 7.4 per cent of the stem borer eggs and that also at irregular intervals, *e.g.*, once in the first set of released plots on the 15th May, once in both the sets on the 2nd and 3rd of June and again in the first and the second set of released plots on 29th June. Had it not been so, the increase in parasitisation, however insignificant, should have followed a regular trend, as the *Trichogramma* wasps were released continuously at weekly intervals. The sporadic nature of occurrence is also proved by the fact that an intensive search for stem borer eggs often brings forth a few *Trichogramma* parasitised eggs in localities where no regular releases are carried out.

1944—The trial during 1944 was carried out at Mansurpur Sugar Factory Farms, Muzaffarnagar, on the same lines as adopted during the previous year. Due to the curtailment of the area under Co. 312, the replications could not be well segregated, although the treatments remained well separated. Due to delayed sowing and consequently late germination of the crop, only five and ten releases were carried out respectively in the 1st set and 1st plus 2nd set of released plots instead of six and twelve. The releases of *Trichogramma* wasps were made in two shifts, commencing from 10th May to 16th June and continued till the 20th July at weekly intervals. The observations on egg and borer population were collected by examining 3 per cent of the total row length, instead of one per cent in the previous year.

The egg deposition by the stem borer, *A. sticticraspis* reached its maximum during the last week of May when 7366, 6660 and 15706 eggs per acre were recorded from the control, 1st set and 1st plus 2nd set of the released plots. No parasitisation of the eggs was observed at the maximum egg laying period or afterwards till the first week of July except in a single instance, when 0·7 per cent eggs were parasitised in the control plots on 27th May. It was in July-August when the temperature had considerably gone down and the atmospheric humidity increased due to about 7″ rain that 4·6 per cent eggs were parasitised on the 7th July and 100 per cent on the 2nd August under the 1st set of released plots. Here, of course, the last shift of releases was carried out as early as the 9th June. Parasitisation of the order of 100 per cent on 13th July, 47 per cent on 25th July and 56·3 per cent on 8th August was recorded from the 1st plus 2nd set of released plots though the parasite releases had actually ceased on the 20th July.

The releases during May and June were carried out at a time when the average maximum temperature was high and the percentage relative humidity was low as in the previous years. The highest maximum temperature ranged from 105° to 113°F. during the period under

reference, while the lowest humidity recorded was of the order of 10 per cent. It was under such conditions that a single instance of parasitisation was recorded from the plots where no releases were carried out. This particular instance supports the previous contention regarding the sporadic occurrence of *Trichogramma.* The parasitisation observed in the 1st set of released plots on the 7th July and 2nd August lends further support to the natural and sporadic occurrence of *Trichogramma* as no wasps were released in these plots after the 9th June. The parasitisation observed in the 1st plus 2nd set of released plots on the 13th July, 25th July and 8th August may be taken to be the results of colonisation of the wasps as releases were continued in these plots till the 20th July. But the irregular trend in parasitisation at a time when the host egg population was extremely thin rules out this possibility. The only instance of parasitisation on 13th July occurred at a time when releases were in progress is not enough to prove the efficacy of the colonised wasps. All these instances should be attributed to the natural occurrence of *Trichogramma* which is often met with in the fields at this part of the season.

The parasitisation of root borer eggs was olso observed in July-August when 14-48 p. c. eggs in the 1st set of released plots and 21-29 per cent in the 1st plus the 2nd set were parasitised by *Trichogramma* against 10 per cent in the control plots. The occurrence of *Trichogramma* in the 1st set of released plots where the releases were stopped as early as the 9th June along with parasitisation observed in the control plots leaves little doubt regarding the activity of some natural strain of *Trichogramma* during the monsoon months. This has been proved by observations in subsequent years when *Trichogramma* colonisation work was not in progress.

Factors responsible for the failure of Trichogramma

There are three important factors influencing the successful colonisation of *Trichogramma viz.*, (1) density of the host egg during the release period, (2) favourable atmospheric conditions for survival and multiplication of parasites and (3) capacity of the parasites to readily parasitise the host eggs.

A study of the resume shows that some of these factors have been stumbling blocks in the success of the colonisation experiments from 1941-1944. In 1941 trial, the density of the host egg population was high in May and afforded considerable chances for the *Trichogramma* wasps to parasitise the stem borer eggs, but no parasitisation. was observed. In June, stem borer egg population rapidly declined due to 5 inches of rains early in the month and was almost nil in July In 1942 trials at Meerut, the egg population was very low indeed during the entire release period for *Trichogrmma* to show itself. While in 1943 and 1944, the stem borer egg population was never heavy enough for the effects of *Trichogramma* to be felt to any appreciable extent. Whatever parasitisation was observed it was due probably

to the natural occurrence of *Trichogramma* than due to the relased wasps. This is proved by the sporadic case of about one per cent parasitisation recorded from the control plots in May 1944 where the steam borer egg population was more than twenty five thousand per acre. It is, therefore, quite reasonable to suppose that *Trichogramma* failed to colonise mainly due to the scarcity of the stem borer aggs. The extreme advocates of the benefits of *Trichogramma* releases claim that the wasps will seek out egg clusters even in fields where only a few unparasitised host eggs are present and a complete control will be brought about. But our observations do not support this view. Rather they confirm Wolcotts' (1943) contention that the actual releases show no such results when hosts' aggs are scarce. He goes so far as to say that '*Trichogramma* is more rapidly discouraged in his search for eggs than is the entomologist'.

Next in importance to the density of the host egg population is the factor of the favourable atmospheric conditions necessary for the survival of the parasite in the field. In may 1941 the average maximum temperature usually ranged between 104°F. and 109°F. though sometimes the highest maximum temperature recorded was 111°F. The percentage relative humidity mostly ranged between 16 and 28 per cent in the afternoon though sometime the record went as low as 10—13 per cent. It may be because of such adverse atmospheric conditions that no parasitisation of stem borer eggs was observed during May when the density of the host egg population was heavy in comparison to the density recorded at the corresponding period in subsequent years.

In 1942 the atmospheric conditions should have been more severe at Meerut than what has been recorded at Muzaffarnagar observatory, where the average maximum temperature ranged from 102° to 109°F, while the highest maximum recorded was 112.5°F. during June. The lowest relative humidity figure recorded was 7-10% These adverse conditions coupled with a low density of host egg population brought about a complete failure of the parasite to establish itself. In 1943 the average maximum temperature was more or less similar to the two previous years, though the highest maximum reached 115°F. in May and 112°F. in June. The lowest figure of humidity noted was of the order of 3-9 %. The occurrence of *Tricho-gramma,* though amounting to an insignificantly low percentage of parasitisation, under such adverse conditions cannot be attributed to anything but to the erratic and sporadic nature of some natural strain. This interpretation gets ample support from the observations recorded during May 1944, when natural parasitisation was observed in control plots only. The highest maximum temperature during the period being 113°F. and the relative humidity being as low as 11 per cent.

This leaves little doubt that the high temperature and low humidity during May and June always interfered with the successful

colonisation of *Trichogramma* wasps. This fact is amply supported by the observations made in the laboratory at Muzaffarnagar[3] where *Trichogramma* were bred on large scale by parasitising *Corcyra cephalonica* eggs (the laboratory host of *Trichogramma*). The temperature of the laboratory had to be kept low by the use of '*Khas*' screens, which were kept continuously wet to keep down the temperature. It was observed that satisfactory parasitisation of *Corcyra* eggs could only be secured when the temperature was below 95°F.

In Barbados, where *Trichogramma* is even now advocated for borer control, Tucker (1930-31) believes that maximum effectiveness of *Trichogramma* is secured at about 90°F. and relative humidity of slightly less than 100 per cent. L. A. Costas (1941) finds the effective range of activity of *Trichogramma* between 68°F and 80°F. In Louisiana, where according to Janes and Bynum (1941) *Trichogramma* has failed, the releases were carried out in July/August at a temperature range of 53°F to 82°F. A perusal of this information along with the observations made at Muzaffarnagar leave little doubt that the atmospheric conditions prevailing in the plains of Uttar Pradesh are not at all conductive for the colonisation of *Trichogramma* during the hot weather of May and June.

As regards the capacity of the parasites to readily parasitise the host, it was observed during the colonisation experiment at Meerut in 1942, that the parasite wasps were rather sluggish when released in the field. This may be due to the influence of prolonged refrigeration lasting from six to eight weeks. This factor might have also contributed its share in the failure of the experiment during May 1941 when wasps refrigarated from four to six weeks, were utilised for field releases. Refrigeration of *Trichogramma* cards could not be avoided as it often became difficult to raise fresh stock of parasites during the hot weather. It is also very likely that the sex ratio might have been disturbed in the over refrigerated stock as Schread and Garman (1933) believe that refrigeration over fifty days changes the normal sex ratio of *Trichogramma* from 3 females : 1 male to 1 female : 1 male. The wasps released during 1943 and 1944 were free from such adverse effects as they never kept in the cold storage for more than one to three weeks.

Review on Trichogramma colonisation experiments in India—It was from the Mysore State that the encouraging reports regarding the utility of *Trichogramma* in the control of stem borer, *A. Sticricraspis* were first received. The Department of Agriculture, Mysore State started a laboratory at Mandya for the multiplication of *Trichogramma* on the eggs of *Corcyra cephalonica* (the laboratory host). This method of controlling borers was found to be highly successful and economical in the beginning, though later Subramanian and Seshagiri Rao (1940) pointed out its limitations. It was on the basis of results achieved in Mysore State that multiplication and trials with *Trichogramma* were first started in northern India at Muzaffarnagar during 1940.

In 1942, the Indian Council of Agricultural Research sanctioned a scheme for trials on *Trichogramma* at eight centres in India, *viz.*, (1) Setabganj (Bengal), (2) Cuttack (Orissa), (3) Sehore (Bhopal State), (4) Lyallpur (Punjab), (5) Muzaffarnagar (U. P.), (6) Kalamb (Bombay), (7) Nellikupam (Madras) and (8) Motihari (Bihar). During the first few years of these trials most of these centres reported satisfactory parasitisation of borer eggs and sabsequent decrease in the stem and root borer population. It was from Muzaffarnagar (U. P.) that the ineffectiveness of *Trichogramma* in the control of the stem borer, *A sticticraspis* and the root borer, *E. depressella* was first reported in 1944. In 1946 it was observed that the trend was in favour of *Trichogramma* only at four places in India, *viz.*, (1) Walchandanagar (Bombay), (2) Cuttack (Orissa), (3) Nellikupam (Madras) and (4) Motihari (Bihar). Trials at these centres were continued on large scale during the period 1946—49. The recent critical review of the work showed that *Trichogramma* had not been a success at any of these centres, Motihari in Bihar being the only exception in India.

Trichogramma as an agent of sugarcane borer control—Breading of *Trichogramma* for large scale liberations in the field against *Diatraea saccharalis* Fabr. was first begun by Cleare in 1921 in British Guiana. In the beginning it was considered to be a promising method of borer control, but later Cleare (1928) himself showed its inadequacy. Flanders (1928) suggested the use of *Sitotorga cerealella* as a laboratory host for quantitative production of *Trichogramma.* Hinds and Spancer (1928—1932) were the first to apply Flander's method on large scale, and reported in favour of *Trichogramma* followed by Smyth (1933), Tucker (1935) and others. Peterson (1930) was the first to point out the ineffectiveness of *Trichogramma* in the control of fruit pests, followed by Allen and Warren (1932) It was Clausen (1935) who souneded the first note of warning regarding the inadequancy of *Trichogramma* in biological control work. Its ineffectiveness in the control of stem borer, *D.saccharalis* was finally established by Janes and Bynum (1941), who went so far as to say that 'The releases of *Trichogramma* are of no value in the control of sugarcane stem borer in Louisiana.' Two years later Wolcott (1943) established that *Trichogramma* was of little utility in the control of stem borer in Puerto Rico. In the light of this information it is no wonder that *Trichogramma* did not prove a successful parasite in the control of sugarcane borer in India.

Summary—Trichogramma colonisation experiments carried out in the Uttar Pradesh during the period 1941-44 are summarised. Observations on stem borer egg population, parasitisation along with the climatic conditions prevailing during the period of releases are given. Causes underlying the failure of the parasite have been fully discussed. A review on the utility of *Trichogramma* in the control of stem borer in India and in other countries has also been given.

As a result of these studies it is obvious that *Trichogramma evanescens minutum* Riley is not likely to succeed in the control of

stem borer, A. *sticticraspis* during the hot weather of May and June. The findings confirm the results achieved in Louisiana and other countries in the West Indies.

Acknowledgements—The author is indebted to Messrs., Z. A. Siddique and Mohammad Jamil for the help rendered in carrying out these trials. The financial assistance received from the Indian Council of Agricultural Research is gratefully acknowledged.

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E. 8—Use of D. D. T. and Benzene Hexachloride Towards the Control of Sugarcane Leaf-hopper (Pyrilla Spp.) in Uttar Pradesh.

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Introduction—Perhaps no other sugarcane pest has received more publicity in the North Indian sugarcane belt than the sugarcane leaf-hopper-*Pyrilla.* In Uttar Pradesh it is locally known as 'AL' to the farmers in the western districts, where it has occurred in epidemic form several times during the last two decades. Its devastating effect on the yield, sucrose, purity and ultimately on the recovery of sugar and *gur* cannot be easily overlooked. Much about it has already been published by the senior author in the *Indian Farming* (1948) in an article on 'Control of sugarcane leaf-hopper (*Pyrilla Spp.*) in the U. P', wherein the cultural and the mechanical methods of controlling this pest have been described. They are briefly reviewed in the following :—

(1) Burning of cane trash, removal of the stubble and ploughing up of the cane fields after harvest

(2) Romoval of the sprouts of the stubble, once at the end of April where ratooning is desired

(3) Destruction of eggmasses or the removal of the two lower most egg-bearing leaves during April and May

(4) Bagging of adults and nymphs in hand nets during the pre-monsoon period (March to June) and killing them in kerosinised water

and (5) Stripping of dry leaves during September and October.

These methods, when applied on co-operative basis on a large scale, have proved their worth beyond doubt ; so much so, that the *Pyrilla* epidemic of 1947 in the western U. P. was completely stemmed and brought to a minimum before the commencement of monsoon rains in July, 1947.

It was in June 1947 that we came across samples of D. D. T. and Benzene hexachloride, and preliminary trials were carried out at Simbhaoli and Daurala in Meerut district. Later, an opportunity was had to confirm the previous findings at Shahjahanpur where *pyrilla* assumed an epidemic form during the post-monsoon period. Results of these trials have been published in the Aannal Report of the Sugarcane Research work in U. P. for the year 1947-48.

Recently an article by Cheema and Sandhu regarding the control of *Pyrilla* by 'Gammexane D025' published in the June, 1949 issue of the *Indian Sugar* and an anonymous letter regarding the use of D. D. T. published in the August, 1949 issue of the same ournal have created a controversy regarding the effectiveness of

D. D. T. suspensions and doubts about the efficacy of 'Gammexane D025'. As we were probably the first in India to try the two chemicals in the control of *Pyrilla*, it is expected of us that at this stage we should reproduce the data available with us on the effectiveness of the two insecticides for the information of the growers and others who are interested in the welfare of the sugar industry.

The organic insecticides used in these trials were :—

(1) D. D. T., 16% emulsion from Lyall Marshall & Co., Calcutta

(2) D. D. T., 50% wettable powder (No. 550) from Geigys Insecticides Ltd., Bombay

(3) Benzene hexachloride from Imperial Chemical Industries (India) Ltd , Kanpur

as (*i*) 'Agrocide 2' (3.5% B. H. C. having 0.46% active gamma isomer)

(*ii*) 'Gammexane D025' (5% B. H. C. having 0.65% active gamma isomer)

The spraying was done 'Mysto' compressed air sprayers, while dusting was carried out by means of 'Peerless' rotary dusting machines.

The population of *Pyrilla* adults and nymphs was ascertained before the application of the sprays and dusts and also a few days after by recording the number of nymphs and adults on 20 plants in net plots varying in size from 1/4 to 1/2 acre, as well as, by judging the increase or decrease in the *Pyrilla* population as a whole in the plots. The effects of the chemicals on the foliage were also noted.

TRIALS WITH D. D. T.

A—16% D. D. T. emulsion

Experiment No. 1—This experiment was laid out in the *Pyrilla* infested ratoon crop of Co. 312 belonging to the cultivators near the Daurala Sugar Factory (Distt. Meerut) on the 14th June, 1947, in scattered plots of 0.6 to 0.9 acre size. The various concentrations of D. D. T. used were based on the recommendations of the suppliers of the chemicals, *viz.*,

(*i*) One gallon of 16% emulsion in 14 gallons of water

(*ii*) One gallon of 16% emulsion in 25 gallons of water

(*iii*) One gallon of 16% emulsion in 50 gallons of water

against control where no spraying was carried out. The trial was conducted on non-replicated basis.

Results—The population of *Pyrilla* nymphs decreased considerably on the 6th day after spraying in the treated plots while no appreciable decrease was observed in the control plots. The lower leaves of the plants had become slightly pale under higher concentrations of the D. D. T. emulsion. Treated plots were almost free of *Pyrilla* during the last week of June when the control plots had a heavy infestation as before. Also as shown in the table there were apparently no significant differences among the results obtained with the different concentrations of D. D. T. Even 1 in 50 seemed quite effective as 1 in 25 or 1 in 14.

Experiment No. 2—Effectiveness of .16% D. D. T. emulsion in proportion of 1 : 50 with water was further examined by carrying out a replicated field trial in the cultivator's field on 24th June, 1947 in the same locality. The data obtained from this experiment are shown in table I. They confirm the previous findings regarding the effectiveness of D. D. T. emulsion.

Experiment No. 3—Large scale application of 16% D. D. T emulsion was carried out at the Sugarcane Research Station, Shahjahanpur during the months of October and November, 1947, when the entire crop all over the farm had severe infestation of *Pyrilla*.

Results—The material sprayed retained a good deal of its toxicity even after two weeks of spraying, but it has been observed that it is slow to act and it was only on the 3rd day that an appreciable decrease in the population or the insect mortality could be noted in the treated plots. The population of *Pyrilla* adults and nymphs continued to decrease in most of the plots. At a few places, however, the number of nymphs slightly increased. This was due to the hatching of eggs from sheltered places in the leaf sheaths. This increase was almost negligible in comparison to the enormous increase observed in the untreated plots. This shows that the hatching period of the eggs was completely covered by the insecticide in plots where D. D T. was sprayed.

B—D. D. T. 50% wettable powder (Geigy's No. 550)

Experiment No. 1—Trials with 50% D. D. T. dispersible powder were carried out at the Sugarcane Research Station, Muzaffarnagar during June, 1947. The population of *Pyrilla* was observed to be 2322 nymphs per 80 plants before the application of the treatments. It was reduced to about 20 nymphs only on the twelfth day after spraying thereby bringing about a reduction of about 98%. 2 lb. of this powder were used with 1 lb. soap in 50 gallons of water. This quantity was found to be sufficient to treat an acre of the crop.

Experiment No. 2—D. D. T. wettable powder was again used on a large scale at the Sugarcane Research Station, Shahjahanpur to control *Pyrilla* during the months of November and December, 1947. The strength of the suspension used was the same as that used in the

month of June at Muzaffarnagar. Except that instead of 50 gallons of the spray, we used 100 to 200 gallons of the spray, depending on the size of the crop.

Results—There as would appear from the table above was heavy infestation in the treated and untreated plots at the commencement of the control operations on 22-11-47. The population of nymphs and adults considerably decreased, as a result of spraying with D. D. T., in the treated plots in (1) while due to the hatching of the eggs and continued changing of nymphs into adults the number of both the adults and nymphs increased in the untreated plots upto the first week of December, 1947. In series (2) and (3) where the crop was treated during the first week of December, a reduction in the population of *Pyrilla* nymphs and adults was observed a week after spraying in the treated plots ; but later on a decrease in the population was noted in the control plots also. This decrease in the untreated plots was due to the lowering of the temperatures due to cold and to which the *Pyrilla* adults are known to be particularly susceptable. The data regarding the decrease in population and the mortality of nymphs and adults observed during the first week after spraying leave little doubt regarding the effectiveness of the D. D. T. wettable powder.

C—Trials with Benzenehaxa chloride—The preliminary trials with B.H.C.('Agrocide 2' having 3·5%B.H.C. and 0·46%active gamma) were carried out in the first week of June at a farm adjacent to the Simbhaoli Sugar Mills, District Meerut. An area of about three acres of the ratoon crop was dusted with the chemical at the rate of 35 lb. to an acre. The knock-down effect of the insecticide was so complete that a heavy mortality of the nymphs was observed in the treated plots in about 10—12 hours. The population of *Pyrilla* nymphs decreased by 95 to 98 per cent after 72 hours of dusting. No adverse effect of the chemical was observed on the plants.

Afterwards another brand of B. H C. 'Gammexane D025' (having 5% B. H. C. and 0·65% active gamma) was tried at Shahjahanpur in the month of October and November, 1947. It was observed that 50 to 60 lb. of the chemical was required to completely cover the entire crown of the green leaves present in the cane at this part of the season. Like 'Agrocide 2' this insecticide also proved very effective and brought about a complete mortality of *Pyrilla* nymphs and adults within two to three days. No reinfestation of the treated crop was observed till the time of harvest in January.

Cheema and Sandhu (1949) have also confirmed our finding on the effectiveness of 'Gammexane D025' in the control of *Pyrilla* in the Punjab.

Economics of the treatments—The cost of the applications of the treatments would always vary from place to place,

depending on the nature and the density of the cane crop. It would also depend on the cost of the insecticide, the quality of labour and the wages paid to them. It has been worked out by us, that during the pre-monsoon period 25 to 50 gallons of spray material is needed to treat an acre of the crop. It would require half to one gallon of the 16% D. D. T. emulsion to treat an acre of sugarcane during May and June, while 1 to 2 lb. of 50%D. D. T. wettable powder would suffice for the same area. The former would cost Rs 10 to Rs. 20 and the latter Rs. 3 to Rs. 6 at the current market rates It would also take about 36 units (one unit= work of one man in one hour), or 4 men working for about nine hours to spray an acre of the crop, costing another sum of Rs. 6 as labour charges. Thus, the total cost of treating an acre of the sugarcane crop would be Rs. 16 to Rs. 26 if 16% D. D. T. emulsion is used and Rs. 9 to Rs. 12 if 50% D. D. T. wettable powderis used.

During the post-monsoon period, *i.e.* in October and November, about 100 to 200 gallons of the spray material will be needed to treat the cane crop of 500 to 800 maunds yield per acre. The actual quantity of 16% D. D. T. emulsion and 50% D. D. T. wettable powder needed to make the required volume of spray material would cost Rs. 40 to Rs. 80 and Rs. 11 to Rs. 22, respectively, while 72 labour units or 8 men working for 9 hours would be needed to spray an acre of the crop. Their wages would amount to Rs. 12 at Rs. 1-8-0 pay day. Therefore, the total cost treating an acre of sugarcane during October and November would amount to Rs. 52 to Rs. 92 with 16% D. D. T. emulsion and Rs. 23 to Rs. 34 with 50%D. D. T. wettable powder.

It was observed as a result of these trials that only 0.32% D. D. T. in the 16% emulsion and 0.2%D. D. T. in the 50% wettable powder was effective to bring about complete control of *Pyrilla*. This means that 16%D. D. T. emulsion can also be further diluted to 0.2%, *i.e.*, 1 part of the emulsion should be used with 80 parts of water. This would bring down the cost of this treatment by an appreciable amount. Even then, the cost of this treatment would remain prohibitive in comparison to 50%D. D. T. wettable powder.

As regards the cost of dusting the crop with 'Gammexane DO25', the cost of the chemical on the basis of 35 to 50 lb.per acre during the premonsoon period works out to Rs.16/- to Rs.22/-, while during the post-monsoon period the dusting at a rate of 50 to 60 lb. per acre would cost Rs. 22/- to Rs.27/-. The labour charges for dusting an acre of crop would be Rs.3/- for 18 labour units (with two men working for 9 hours) during the premonsoon period and it would be Rs. 6/- for 36 labour units(with four men working for 9 hours) in October and November. It is worthwhile mentioning here that it becomes difficult, if not impracticable, to dust a luxuriant and tall cane crop with rotary hand dusting gun. It would be worthwhile to use better

types of dusting machines or power dusting to increase the efficiency and to bring down the cost.

Discussion—The effectiveness of Benzene hexachloride ('Gammexane DO25' or 'Haxyclan' having 5% B. H. C. and 0.65% active gamma isomer) and 50% D. D. T. dispersible powder used by Cheema and Sandhu (1949) in their experiments in the Punjab has been doubted by some anonymous workers in the August, 1949 issue of the *Indian Sugar*, Vol. XII, page 439. The author of this letter has further raised the question regarding the crystalline and amorphous nature of the D. D. T. deposits on the leaf surface. His contention is that a crystalline deposit from the emulsion is more effective and rapid in action than an amorphous deposit from the suspension. He feels that the choice of D D. T dispersible powder had a considerable bearing on the negative results obtained in the Punjab.

It is almost an established fact that Benzene hexachloride has got a quick knock-down effect. As regards its prolonged action our observation is that one dusting carried out during the third week of October when all the stages of the pest were present, eliminated all the nymphs and adults from the crop, and the absence of any reinfestation of the treated crop during the rest of the season indicated that whatever nymphs hatched out were killed. Again, in March, 1948 a wheat crop was dusted at the rate of 50 lb. per acre when the oviposition was in progress and the adult population was very high. Dusting destroyed all the adults and here again we did not come across any reinfestation till the wheat was harvested. All this leads us to believe that 'Gammexane DO25' has also got prolonged effect. These observations are well supported by Muirhead-Thompson (1949), who found it effective even after 13 weeks after the application of the treatment.

As regards the crystalline and amorphous nature of the D. D T. deposits our experience is that the D. D. T. suspension is more effective than the D. D. T. emulsion. The results obtained by Madjinicolaon (1948) Laplante (1949) support the observation.

It appears that the author of this letter has based his criticism on the observations of Hadaway and Barlow (1947,1949) that crystalline deposits from emulsions are more effective towards the destruction of flies than the suspensions. This may be true for flies, but it does not hold good for *Pyrilla* due to the differences in the structure of the mouth parts. The mouth parts of flies are of sponging and sucking type, while those of *Pyrilla* are piercing and sucking. The flies are affected by contact as well as by feeding on the crystalline deposits present on the surface treated with emulsions, while in the case of *Pyrilla* it is the contact action alone which brings about mortality. The chances for *Pyrilla* of coming into greater contact with an amorphous deposit are much more than in the case of crystalline deposits.

Conclusions—

(1) One part of 16% D. D. T. emulsion with 50 parts of water and 2 lb. of 50% D. D. T. wettable powder in 50 gallons of water, are effective in destroying the *Pyrilla* nymphs and adults within a period of 10 to 15 days.

(2) Five per cent Benzene-hexachloride ('Gammexane D025') having 0·65% active gammaisomer brings about a heavy mortality of *Pyrilla* nymphs and adults when applied at the rate of 35 to 50 lb. per acre during the premonsoon and 50 to 60 lb. per acre during the postmonsoon periods.

(3) The mortality of the insects is observed after 72 hours of spraying with D. D. T. and after 10 to 12 hours of dusting with B. H. C.

(4) The two chemicals *viz.* D. D. T. and B. H. C. remain effective for quite a long period as reinfestation was not observed in the treated plots.

(5) The actual quantities of D. D. T. required to eliminate *Pyrilla* amount to 0.32% in the 16% emulsion and 0.2% in the 50% D. D. T. wettable powder.

(6) There is scope for further dilution of the 16% D.D.T. emulsion to 0.2% *i.e.* one part of emulsion in 80 parts of water.

(7) Twenty-five to fifty gallons of the spray shall be required to cover the foliage thoroughly during April, May and June and 100 to 200 gallons during October and November depending upon the density of the crop.

(8) The chemicals are not expected to effect the foliage in the proportions in which they have been used.

Acknowledgements—The authors are grateful to Dr. B. K. Mukerji, Director, Sugarcane Research and to Shri A. D. Pant, Cane Commissioner, U. P., for the pains taken to secure the chemicals when they were not easily available and for the keen interest shown in the control of *Pyrilla*. The authors are also indebted to Shri Mohd. Jamil, Junior Entomological Assistant and to Shri D. P. Gupta, Assistant Cane Development Officer for the help they gave in conducting these trials. The financial help received from the Indian Central Sugarcane Committee is also gratefully acknowledged.

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E. 9.—Biological Control of the Early Shoot Borer of Sugarcane—*Argyria (Proceros) sticticraspis*, H, *Trichogramma minutum* Riley in the Madras State (South India)

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Introduction—The control of the early shoot borer of Sugarcane-*Argyria (Proceros) sticticraspis*, H. has been one of the major problems engaging the attention of Economic Entomologists, eversince a serious study of this branch of science was initiated in this country. Mechanical removal and destruction of the infested plants,-trapping the adults, using insecticides like arsenical poisons, fluo-silicates etc., swere tried off and on and later innovation was the earthing up of the young plaints with a view to smoother the egg masses and young caterpillars. The pest being essentially an internal feeder, none

of these methods afforded any appreciable degree of relief and the problem had, therefore, to be kept in cold storage for some time. The possibilities of utilising biological agencies for the control of the borer was a still later idea adapted from the experience of other countries. The Mysore stage was first to explore the utility of *Trichogramma minutum R.* and some interesting results are reported. A co-ordinated scheme of work was later organised by the Indian Council of Agricultural Research and field scale experiments were initiated simultaneously at different centres like, Cuttack, Bengal, Bombay and Madras by 1942 and continued in the State till 1950. The following is a short account of the work done so far and the results obtained thereof.

Previous history in other countries and in India Cleare, (1921) in British Guiana was the first to attempt the breeding of *Trichogramma* for releases against the cane borer, *Diatraea saccharalis,* but the parasites were reared on the host itself and later liberated in the field.

Flanders (1926) tried the laboratory rearing of *Trichogramma* on various host material and found that eggs of the grain moth (*Sitotroga carealella* Oliv.) suitable for the large scale multiplication.

Hinds and Spencer were the first to adapt Flanders' method for the mass rearing of the tiny wasps and later colonise them in the field against *Diatraea saccharalis.* They experienced a marked increase in the egg parasitization during 1927, 1928 and 1929 wherever the parasites had been released and a reduction in the borer incidence of the plantation during 1929.

Hinds, Osterberger and Dugas have recorded the following observations after a study for six seasons:—

"*Trichogramma* colonisation tests as made in fields of corn and sugarcane in Louisiana during the seasons of 1927 to 1932 have shown consistently beneficial results in the rapid increase following in the rate and proportion of borer eggs destroyed. They have shown consistent, and regularly proportional decreases in borer damage as measured by the percentages of joints bored, the number of emergence holes found and the moth population produced per acre. They have shown regularly a very substantial increase in the number of millable stalks produced, amounting to about 6000 per acre. The corresponding increase in the weight of millable cane has amounted to more than three tons per acre. With this there has been found an average increase of over 20 lb. of sugar per ton of cane produced in protected areas. This does not mean the complete control of the borer and never will—but it appears to show one practicable, easy, usable and a very dependable and profitable method which may be used in decreasing borer damage in Louisiana."

Tucker (1935) reporting on 6 years' investigations in Barbados against *Diatraea saccharalis* states "Whilst an adequate statistical proof of increased general and average parasitism may not have been obtained, there is a definite indication that the early mass releases of parasites each year, achieve their purpose of increasing this mortality in a manner which results in a measurable decrease in the number of 'effective borers' which survived over the period of liberation and therefore of the final damage to the crop".

Smyth (1933) reporting on the technique in the mass production of *Trichogramma* used to control the cane borer in Peru says, "significant is the fact that as a result of mass colonization of *Trichogramma* wasps reared by this technique, borer damage was so reduced that the purity and sucrose of the cane (and hence the sugar content) showed a very considerable increase, in a large series of fields colonized with parasites, over those registered in other fields of the same plantation not so colonized".

Mass liberations of *Trichogramma* have been tried as a control for insects other than the sugarcane borer. Peterson (1930), in experimenting with the parasite against the oriental fruit moth (*Grapholitha molesta* Busck.) mentions: "Preliminary field tests in a peach orchard indicate that small liberations of from 300 to 1000 adults per tree are not sufficient to produce parasitism among aggs in adjacent trees".

Allen and Warren (1932) working with the same insect have summarised their findings to the effect that "the increased production of fruit did not justify the added expense. The releases were made at the rate of 55,000 parasites per acre during each of the two seasons."

Schread and Garman (1933) have recorded their conclusions as follows:—

"The average percentage parasitism in 1931 in three orchards where no *Trichogramma* were liberated was 23, in those orchards where they were liberated it was 45 per cent. Observations and field counts indicated that high *Trichogramma* parasitism was correlated with reduced infestation, but the reduction was not enough in some cases to be called commercial control."

List and Davis (1932) in their trials against the codling moth (*Carpocapsa pomonella, L*) have found that during seasons of high natural parasitism little is accomplished by either mass liberations or by colonization of *Trichogramma*. During seasons of low natural parasitism, liberations can be responsible for a pronounced parasitism, but in no case has this been sufficient to show a marked control of the codling moth as indicated by fruit examinations.

Schread (1935) carried on some co-operative experiments with A. W. Morrill and the Associated Seed Growers of Milford to determine the value of releasing *Trichogramma* for the control of the European corn borer, *Pyrausta nubilalis*, Hon have concluded that "after parasite release at the rate of 10,000, 20,000 and 30,000 per acre, the data accumulated throughout the season were not significant from the standpoint of colonization. The average parasitism in the adjacent areas was slightly higher than in the colonized areas, whereas during the secondb rood the results were the reverse. The average parasitism during the second brood in the check plots was approximately five times as great as found in the colonised areas."

Clausen (1935) has stated that "In recent years efforts have been made to extend the usefulness of this parasite by rearing the species in enormous numbers on grain moth eggs and liberating them in the infested fields and orchards early in the season. This has been tried on a number of important pests of field crops and orchard tree, but the results thus far have not been conclusive. This work is still in the experimental stage, and at present it is not recommended to growers at field practice."

Subramaniam, V. (1941-42) first initiatied critical studies in Mysore regarding the efficacy of these parasites against the early shoot borer *Argyria sticticraspis*. He mentions that "the releases of the parasites alone in the cane fields will not give the maximum borer control, but other borer control methods recommended by the Mysore Agricultural Department, should also be adopted in addition to parasite releases." Similar field scale experiments have since been laid out since 1942 in various states of the Indian Union like Madras, Cuttack, Bengal, Bombay etc.

Object—The scheme was started at Madras with the following objects in view :—

(1) Whether a systematic colonisation of *Trichogramma minutum R* would bring about any appreciable increase in the percentage of parasitism of the eggs of the early shoot borer *Argyria sticticraspis*

(2) Whether there would be significant reduction in the incidence and damage by the borers as a result of the increased parasitism

(3) Whether the yield of cane would be in any way influenced by the elimination of the insect factor

(4) Whether the additional yield, if any, would be commensurate with the expenditure involved.

LIFE HISTORY OF THE HOST AND THE PARASITE

Argyria sticticraspis, H—The female lays her thin oval pale-white eggs in rows, each egg overlapping the next one, generally on the under-surface of the leaves. Individual eggs vary from 0.7 to 1.0 mm in length. The average egg laying capacity of a female has been recorded to be about 230 eggs. The egg-period lasts from 3 to 4 days. The newly hatched larvae first feed by scraping the surface of the leaves and later suspend themselves with silken threads and eventually reach the main stem below. On getting at some suitable spot, they bore inside and feed on the internal tissues. The larval period extends to about 35 days after which the caterpillar pupates inside the stem itself. The adult emerges in 6 to 10 days and the entire life-cycle may be completed in about 45 days. The upper wings of the moth are dirty brown in colour, the lower ones being slightly paler.

The activity of the borer is evinced by the characteristic withering of the central shoots. The affected tiller invariably dies and the damage may often be as high as 40%. The peculiar tillering nature of the sugarcane crop generally compensates the initial loss but the mortality of the large number of first shoots may eventually extend the duration of the crop, which is not desirable. Experience gained so far indicates that the pest is particularly severe in the main crop planted in March-April, the hot weather being considered to be favourable for the prolific multiplication of the pest.

Trichogramma minutum Riley—This is an egg parasite with a confirmed polyphagous taste. The life-history is briefly as follows :—

The female thrusts her eggs inside the host material. The grubs hatch out in due course and feed on the contents. The adult emerges in 7 to 10 days, depending upon the weather conditions, the period being short under higher temperatures. The tell-tale indications of the activity of the grub inside are that the parasitised eggs turn blackish in colour on the 3rd day.

Apart from its polyphagous habits, the parasite possesses a few additional advantages in its having a short life-cycle and amenability for rearing under laboratory conditions. It has on this account been used as a biological agent all over the world against a variety of crop pests.

Material and method—The wasps were multiplied on a mass scale at Coimbatore on the eggs of *Corcyra cephalonica, H* and the parasitised cards despatched to Nellikuppam by post. The adults were released on their emergence, in selected fields.

The experiments were first planned with two treatments, *i.e.*, six and twelve weekly liberations, each having two replications. The

area of each plot was three acres in extent for all the years under study, and due care was exercised to locate them sufficiently away from one another so as to eliminate the possibility of the parasites migrating from one block to another. Minor details like preparatory and after cultivation, seed rate, manuring were as uniform as possible. The releases were commenced 45 days after planting and were continued at weekly intervals at the rate of 8000 parasites per acre per release and the " modus " was according to the accepted technique.

With the experience gained from 1942 to 1946, it was gathered that the six liberations did not have the desired effects, nor was the number of 8000 parasites considered enough. The experiments were therefore modified to only one set of twelve liberations with 16,000 parasites per acre, the releases themselves being commenced from the time of the germination of the crop. The results were assessed by recording (*a*) Egg parasitisation, (2) Borer incidence and population and (3) Final yield of cane. The degree of natural parasitism, and infestation was first recorded during the month of April, prior to the releases from 1944 onwards, so as to trace the subsequent progress. The releases were invariably commenced in May and the data collected once a fortnight upto the end of July. The egg parasitisation data are discussed under two periods *viz.*, the two fortnights of May and the first one of June as the first period and the other three fortnights upto the end of July, constituting the second. Eggs of *Argyria sticticraspis* occured in abundance upto June, after which those of *Diatraea venosata* also were fairly common.

The fields were divided into ten sub-plots of 30 cents each and examinations for the egg masses were conducted in randomised rows once a fortnight in 1 per cent of the area during 1943 to 1946, but the area was extended to 3 per cent from 1946-47 to 1949-50. The plants were searched thoroughly, leaf by leaf, and the eggs found on them examined for the percentage of parasitism.

The incidence and the population of the borers were also assessed on similar lines. These were recorded at harvest also, but they have hardly any bearing on the main investigations as they were contemplated against the early shoot borer.

Harvest—The canes were harvested sub/plot wise in the treated as well as in the control plots and the yield totalled and compared. Analysis of the juice also was made from random samples taken from the bulk produce.

Economics—The cost of production of *Trichogramma* comes to about Rs. 2/- per liberation, per acre.

Results—(*a*) *Egg parasitisation*—The data are discussed below :—

1942-43—As the experiment could not be started in time, in properly laid out plots, the first year of the trial was taken more as a period of preliminary study and the data have, therefore, not been taken for discussion.

1943-44—Initial parasitisation counts were not recorded during this year. The parasitisation in the control during the first three fortnights was 2.2 per cent, which gradually appreciated to 11.4 per cent by the end of July. The six-liberation plots did not reveal either the presence of eggs or parasites till the 2nd of fortnight of July and the aggregate parasitism for the season was only 7.0 per cent. The egg population was higher in the twelve-liberation plots and consequently the parasitic activity was more in evidence. From a beginning of 38.9 per cent by earlier part of May it shot up to 100.0 per cent by June, with a subsequent decline. The average for the entire season being 44.5 per cent.

1944-45—Only the six-liberation plots had a preliminary parasitism of 13 2 per cent. Though no activity was recorded in the control during the earlier stages, an appreciable percentage of 34.3 was recorded during the second fortnight of May. It began to depreciate later, rising up again to 49.6 per cent by the end of July. The releases appear to have amply augmented the natural parasitism in the six-release plots, as it rose up to 62·8 per cent during June and again to 85.0 per cent by July, in spite of the fact that artificial fillip was stopped by June. The average was 38.2 per cent. The twelve—liberation plots also exhibited a good degree of parasite activity, the notable feature being that it appreciated to 100.0 per cent during July, with the aggregate average as 32.1 per cent.

1945-46—The notable feature for this year was the high degree of natural parasitism in the field, the figures being 30.9 per cent, 33 1 per cent, and 59 1 per cent for the control, six-liberation and twelve-liberation serus respectively. Subsequent observations show that the parasitic activity in the control began to dwindle down steadily for the first three fortnights, but increased later during Juue-July—the average being 26·8 per cent. The level of parasitism was steadily kept up in the six-liberation plots until it rose up to 96.0 per cent during July, in spite of the fact that the releases were stopped by June. The aggregate average was 51.8 per cent. The higher degree of natural parasitism in the twelve-release plots does not appear to have been maintained subsequently, as it was fluctuating between 16.0 per cent to 70.0 per cent with an average of 28.1 per cent. The probable reason may be the break down of the irrigation facilities in one of the replications. From the progress of the parasites in the control and six-liberation plots, it looks as if the current season has been somewhat favourable for the parasites.

1946-47—The observations were restricted to only the twelve liberation plots and the control from the year onwards. The initial parasitisation was only 4.7 per cent in the control as against 35.0 per cent in the treated plots. No subsequent parasitic activity was noted in the controls whereas it fluctuated from 12.0% to 54.0% in the colonised plots, the average for the season being 21.3%.

1947-48—No initial parasitisation was recorded in the control, while it was 11.4% for the treated plots. A certain amount of steady progress in the natural parasitisation was noticeable in the controls, as it rose up from 4.8% to 33.1% with a gross average of 19.3%. The initial parasitisation and subsequent higher parasitisation was perceptible in the colonised plots, the increase being progressive from 12.2 per cent to 58.5% with an average of 38.9 per cent.

1948-49—The initial parasitisation on the control was 27.2% as against 14.6% for the treated plots. Parasitism in the control began to slowly depreciate until it reached its lowest ebb of 5.9% (average being 17.3%), whereas the treated plots showed a maximum of 56.5%, with an average of 32.2%.

1949-50—The natural parasitism was found to be fairly high in both the areas; the figures being 42.9% in the control and 38.8% in the colonised plots. The parasitic activity withered down subsequently in the former, with no figures for the later part of the season, and the average was 8.5%. The high initial parasitism in the treated areas was augmented by the liberation, the percentages fluctuating from 27% to 45.6% with an aggregate average of 34.4%.

These data indicate that the colonisation of *Trichogramma* does augment the activity of the parasite as borne out by the uniformly higher percentages recorded in the treated plots. The limiting factors appear to be severe drought, failure of irrigation sources etc. The natural parasitism recorded in the control plots have been fluctuating with the indications of gradual increase towards the latter stages. The essence of these findings appears to be that the releases maintain the parasite activity, often augmenting the one in nature, at a high level during the earlier stages of the crop (May—June), when the oviposition by the borer *Argyria* is at its peak, which naturally results in the reduction of the pest population. Subsequent increased activity either in the control or in the treated plots is generally not of much consequence, since bulk of the damage is already wrought by the earlier broods of the borer.

A detailed discussion of the data, year by year, is not considered necessary, as their indications have been more or less uniform during all the years. A cursery analysis of the figures as traced from the initial data shows that both the incidence and population are steadily on the increase in the control and colonised plots. But the virulence is kept within limits in the colonised plots, while it has

gone on unchecked in the controls. It may also be seen that the incidence has waned down from 1947—48 onwards.

The increase in yield has varied from 2.78 tons to 10.35 tons per acre, except in two years, when it has been less.

Summary—The following are the broad conclusions that can be arrived at from the data available :—

(1) *Argyria sticticraspis*—H. forms the major stem borer pest in the Madras State and its eggs form about 80% of the total stem borer eggs

(2) *Trichogramma minutum* is commonly recorded as a natural parasite on the eggs of *Argyria*. Their activity can be augmented to an appreciable degree by artificial colonisation

(3) The effect of the releases is also reflected in the fact that the increase of the borer population is kept within bounds in the treated plots, whereas it was steadily increasing in the control

(4) The colonised plots having higher degree of parasitism and lower infestation invariably give higher yields, but even from a cursery and later by a statistical analysis, the inter-relations between the different aspects have not been sufficiently borne out with a convincingly significant margin

(5) ADDITIONAL YIELDS HAVE BEEN RECORDED FROM THE COLONSIED plots in five years out of 7 years experiments.

Acknowledgement—The scheme had been in charge of Sri S. Ramachandra Iyer, the then Assistant Entomologist and now the Government Entomologist, Sri. C. Krishnamoorthy, the Assistant Entomologist and Mohamed Basheer, Assistant Entomologist, Sugarcane Pest Scheme during the successive periods and the material for this paper is at best a compilation of the work done so far from 1942 to 1950. Acknowledgements are due to the staff who worked in the scheme and also to Messrs East India Distilleries and Sugar Factoies Ltd., Nellikuppam, South India for having placed their estates and rendered all the facilities for the conduct of the experiments.

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E. 10.—A Method to Assess the Damage Caused to the Sugarcane Crop by Insect Pests

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The problem of the assessment of the damage caused by the insect pests of sugarcane has suddenly assumed particular significance during the last two years on account of the acute shortage of sugar. When increased production in every branch of national endeavour, especially, in the vital field of agriculture has become urgently necessary for our very existence as a free nation, the need for having exact data of the damage caused by insect pests, and the loss suffered by the cultivators in the yield of cane and the mill owner in the recovery of sucrose needs no emphasis. The possession of this knowledge is an absolute pre-requisite for the entomologist to plan and execute his control measures on a rational and economic basis. It has been a practice in the past, indeed it is a practice even today for entomologists to record insect outbreaks and then devise in great hurry control measures to achieve quick results. This is neither a rational nor satisfactory way of tackling a problem of such a fundamental nature. If we succeed in placing some exact data atleast before the administrator, it will make him realise the magnitude of our problem which is indeed a national problem. Ever since the Government of India granted protection to the sugarcane industry in 1932 "to provide for the fostering and development of sugar industry in British India" the acreage under sugarcane has gone on steadily increasing till today, the area under sugarcane is about four million acres. This process of bringing large areas under sugarcane was facilitated by variety of new canes

bred in the sugarcane sub-station of Indian Agricultural Research Institute at Coimbatore. One of the problems that has come to the forefront as a result of this increase in acreage is the problem of insect pests of sugarcane. Munro (1929) observed "many insects that are in their primordial state no more than scavenger living on refuse, assumed the status of the major pests when their power of multiplication is increased by a generous and bountiful food supply." As is well known insects multiply in geometrical progression and when their rate of increase is facilitated by growing of a single crop in a continuous belt, the result that is produced is often times disastrous. We may here quote Thompson (1930) who observed "since organisms increase in geometrical progression the survival in each generation of even two or three females above the number necessary to maintain the population at an even level, may produce in a relatively short time disastrous results. For example, one female of a species with a three fold increase per generation will have in the twentieth generation about 8,000,000 descendants. This explains the phenomenal spread and catastrophic destructive power of certain introduced insects". A bountiful food supply grown in a continuous belt aggravates this problem of multiplication of insect pests to an alarming degree. As Munro has observed "the amount of food available to an insect is naturally a vital matter in relation to that insect's development and increase, and it is by increasing the food supply artificially that man himself creates the majority of his insect problems. The growing of crops in large but compact areas and the cultivation of pure crops of only one plant are wholly artificial phenomena. They afford the insect an uninterrupted and large supply of its host plant, and thereby favour its increase.

As insects living on wild *Solanaceae* find its host plants scattered and mixed with plants which have no interest for it, but the same insect arriving in a potato field finds an unlimited and uninterrupted food supply. When its numbers increase, dispersal is no longer necessary to ensure adequate feeding or breeding ground. The risks which such a dispersal, necessary when the insect is living in a natural environment, entails are avoided in the potato field and by the mere act of cultivating his crop as pure crops extending over large areas, man favours insect attacks on these crops."

So we see the importance of the insect pests of sugarcane and the serious damage that they can cause. But the problem of the assessment of damage caused by insects is no easy problem. The scientific aspect of the problem itself bristles with difficulties and even in the scientifically advanced countries of the west no satisfactory solution has been arrived at.

In India very little work has been done with any degree of scientific exactitude to assess the damage caused by insect pests of sugarcane. Haldane (1937) made a survey over the supplies of cane

delivered to the factories in north Bihar and eastern area of the United Provinces. As a result of this survey it was observed that the sugarcane crop in North Bihar and eastern U. P. is infested with various species of borers. Associated with the injury caused by the borer the plant tissues were also found subject to attacks by micro-organisms responsible for the destruction of large quantities of sugar. The annual loss due to the borer reaches very large sums and about 4 per cent of the weight of the crop was estimated to be damaged in this way. The money value due to the loss of sugar due to both borers and diseases worked out at Rs. 17,50,00 in the ten factories in a season of five months, quoting sugar at Rs. 6 per maund. The recurring loss to the Government was estimated to about Rs. 4,30,000 taking the sugar duty as Rs. 1-8-0 per maund. The total loss in the 65 factories that were operating in north Bihar and eastern U.P. during the time was estimated at Rs. 1,13,75,000 for borers etc. and Rs 28,00,000 loss to the exchequer or grand total of about Rs. 1,41,75,000 was lost to Bihar and eastern U. P., the majer sugar growing tracts of India.

Pruthi and Narayanan (1939) made a statistical study of the loss caused by borers and termites to mature sugarcane at Pusa. The work was conducted in two years, 1935 and 1936 and it was observed that obout 7% canes were found infested by one pest or the other and a total loss in weight due to all pests combined was 5.77 ± 1.71 per cent (significant) in variety Co. 331 during the first year. The canes infested by various pests also showed deterioration in the quality of juice, the stem-borer proving most harmful, the juice of canes attacked by this borer having 13.07%, sucrose against 16.2 percent of the healthy canes. The top-borer infested canes had 15.50 per cent, whereas the root-borer category had 17.37 percent. The purity of the canes was also affected in the same order. It should be noted that the root borer attacked canes always weighed more and gave a greater percentage of sucrose recovery.

The work was further expanded during the following year and observations were made in five common varieties of cane grown at Pusa at that time and they were Co. 331, Co. 313, Co. 299, Co. 213 and Co. 210. About 60% of canes of Co. 331 and Co. 299, 70% of Co. 213 and 80% of Co. 313 and Co. 210 were found infested by one pest or the other. And the total loss in weight due to all pests combined was significant in all varieties except Co. 299. Co. 210 suffered most (12.8 ± 2.22 per cent), Co. 313 came next ($11.62 \pm 2.22\%$), followed by Co, 213 (9.10 ± 2.22 per cent), Co. 331 (7.90 ± 2.22 per cent) Co. 299 suffered the least—$3.92 \pm 2.22\%$ (not significant).

The object of this paper is to set forth a new method to assess the damage caused to sugarcane crop by insect pests. It is not a perfect method, for the simple reason that in a problem of this kind where so many other complex factors are involved, it is very difficult

to evolve a perfect method. The difference between the method that I now suggest for the consideration of the conference and the one that Prutbi and myself (1939) have published in the *Indian Journal of Agricultural Science* is that whereas in the present case attempts are being made to assess the loss caused by the insects during the whole of the growth phase, in our previous contribution, the loss has been estimated on the basis of damaged canes at the time of harvest only. We have to select a number of villages at random in the cane growing districts as is done by the Indian Council of Agricultural Research for their crop cutting experiments. This is done on the information provided by the villgage *patwaris.* Roughly we may select 10% of the villages in each *taluka* at random. In each of these villages six fields growing sugarcane are selected and periodic observations on the incidence of pests, namely the top, the stem, root borers, white fly, *Pyrilla* etc. are made and an idea of the population of the pest per acre is determined at intervals of one month till hibernation. In areas where there is no clear cut winter season and where there is no hibernation, the monthly observation can be stopped about two or three months before the canes are cut and sent to the mills for crushing. At the time of harvest the loss caused by all the pests put together is obtained by sorting out the healthy and insect pests attacked canes separately and weighing them and finding the weights of these two different categories and adjusting the weight of the infested canes on the basis of the healthy cane. Thus the loss suffered by the cane at the time of the harvest or two or three months prior to it is obtained. Now to make allowance for the loss caused by the pests during the period from February to November, we find the regression of the adjusted weight at the time of harvest to the average population and the rate of change of the population of the various pests. By making use of the regression equation,

$$
\begin{aligned}
(y-\bar{y}) = {} & a_1 (x_1-\bar{x}_1)+a_2 (x_2-\bar{x}_2)+a_3 (x_3-\bar{x}_3) \\
& +a_4 (x_4-\bar{x}_4)+a_5 (x_5-\bar{x}_5) \\
& +b_1 (z_1-\bar{z}_1)+b_2 (z_2-\bar{z}_2)+b_3 (z_3-\bar{z}_3) \\
& +b_4 (z_4-\bar{z}_4)+b_5 (z_5-\bar{z}_5)
\end{aligned}
$$

y = Yield adjusted at the time of harvest

x_1 = population of top borer z_1 = rate of discharge of top borer

x_2 = population of stem borer z_2 = —do—

x_3 = population of root borer z_3 = rate of discharge of top borer

x_4 = population of white fly z_4 = rate of discharge of top borer

x_5 = population of Pyrilla z_5 = rate of discharge of top boror

it will be possible to obtain the total weight of canes free of pests. From this the total loss caused by the pests to the sugarcane can be estimated. This work can be supplemented by some work by the plant protection organisation carried out on the same lines as the crop cutting experiments. For this a number of pairs of plots, two or three, are selected in each of the six villages and plant protection methods are adopted in one set and the other kept as a control. This will enable us to estimate the increase in yield of cane by adopting plant protection methods.

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SUGARCANE MYCOLOGY

My.1—A Note on the Breeding and Testing of Sugarcane Varieties Resistant to Three Major Diseases with Particular Reference to Red Rot

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The evolving of varieties resistant to atleast the major diseases such as, Red rot, Smut, and Mosaic is now given top priority in the breeding programme of practically all sugarcane breeding stations. The prospect of the cane breeder is far from discouraging as in *Saccharum* a range of varieties and species is available whose behaviour with respect to diseases is known and which fortunately cross freely *inter se.* The disease that has claimed the serious attention of sugarcane pathologists and breeders is Red rot which during recent years assumed such large proportions in India, Louisiana, etc. Next in importance is the Smut disease and it causes much damage when a susceptible variety is cultivated continuously. Mosaic disease of cane is wide spread througout the world wherever cane is grown, most of the old cultivated varieties being highly susceptible.

1. *A Red-rot*—No other disease of cane in India causes such complete destruction as Red rot. The disease was first described by Went in 1893 from Java. In the Godavari delta in India, Barber noticed it in 1901. Butler in 1906 reported that the disease caused severe damage in India. In 1908, Lewton Braine from Hawaii and Edgerton in 1910 from Louisiana reported its presence.

Red rot caused by *Physalospora tucumanensis Speg.* (*Colletotrichum falcatum* Went), is one of the major diseases of Sugarcane. It causes poor stands and inversion of sucrose in mill cane resulting in low recovery of sugar at the factory.

In its early stages Red rot is not easily discernable, but in well advanced stage, the upper 3rd or the 4th leaf from the top droops and the margin of the leaf begins to wither. Later on the complete top withers. On splitting open the cane, the disease is recognised by the longitudinal reddening, especially when the red colour is interrupted by occasional white patches extending cross-wise of the cane.

In order that the resistance or susceptibility of the thousands of seedlings tested every year may be determined, before they are select-ed for distribution to the Research Stations in the Indian Union for trial, it has been necessary to devise methods of testing them for their reaction to Red rot as well as other diseases. Depending solely on field observations on the natural infection would frequently require several years before the reaction of a variety to Red rot could be evaluated correctly. So the field inoculations are done for testing varieties resistant to diseases.

For Red rot, the most suitable method of study is the field inocu-lation method perfected at the Division of Mycology, Indian Agricul-tural Research Institute, New Delhi, as this gives truer picture of the reaction of the variety to the disease. The inoculations are made by boring the bottom most visible internode of canes with a specially devised punch, similar to a cork borer and with a sterile instrument a piece of a 15-20 day old culture of *Physalospora tucumanensis*, Speg. on oat-meal-agar is inserted into the hole and plugged. To prevent damage to the culture, the punched part of the cane is kept covered with a strip of paper. After 4-5 months the inoculated canes are cut and split open longitudinally along the plane passing through the point of inoculation and the linear spread of Red rot attack above and below the point of inoculation is measured and recorded. The extent of damage in different varities is compared. On the basis of this com-parison each variety is put in the following classes : resistant, mode-rately resistant and susceptible.

In addition to the field inoculation method, the laboratory method adopted by Abbott (1938) in Louisiana has also been pressed into service, as a means of providing information quickly as to the inherent resistance or susceptibility of large number of seedlings before they are raised to the status of Co. numbers. The laboratory method possesses the advantage of being completed in a short time. It consists of determining the rate of spread of the Red rot fungus in inoculated cuttings of mature canes, under conditions favourable for the development of the disease as compared with that in similarly treated canes of standard varieties, the reaction of which in the field and in the laboratory is known. The method of inoculation consists in cutting mature canes into 4-foot lengths and punching in the centre of two internodes of each cane, leaving two internodes between those punched. After inoculation the canes are incubated in saw dust boxes and the Red rot ratings are made after a month on the basis of visual examination of the split canes in comparison with similarly treated cuttings of standard varieties, the Red rot reaction of which is known.

There has been a volume of criticism regarding the laboratory method that it is not suitable for Indian conditions as the main trouble in Louisiana is the rotting of the seed cane after planting, but in India, it is a disease of the growing crop.

Edgerton and Moreland (1920) observe that from the various publications on the subject (Red rot) it is evident that for some reason or the other, the conditions in India are radically different from those in West Indies and Southern United States, including Louisiana and that the Red rot develops in the cane after cutting more rapidly than it does in the growing cane Abbott (1938) found that while laboratory tests of susceptibility to Red rot on cut canes gave a measure of internal tissue resistance, they do not necessarily indicate the reaction of that variety to the disease under field conditions. According to Edgerton and Tims (1934) the fungus may spread very rapidly in a stalk when infection occurs and yet not easily gain entrance to a standing stalk in the field and that the rate of growth of the fungus in the cut stalk may also vary considerably from that in a standing stalk.

It is indeed true that the Red rot problem in Louisiana is quite different from the Red rot problem in India and that their trouble is the rotting of the seed cane after planting and ours is a disease of the growing crop. But, if the laboratory method could give us a workable idea of the susceptibility of the varieties to Red rot in a shorter time under Indian conditions it well help the selection of hundreds of seedlings waiting for selection and despatch in the final year test plot. Atleast the susceptible ones could be rejected. It is obvious that any attempt to classify sugarcane varieties according to the Red rot resistance must be arbitrary to a certain extent. However, some basis of classification is essential. So it was thought that a fair trial should be given to the laboratory method to see whether by this method we could seive out the susceptible ones. Moreover, it has the advantage of being completed in a short time. So a pilot experiment was laid down to compare the field and laboratory methods.

In the first instance 59 Co. varieties of Co. 213 parentage were planted in 10-foot rows with 3 replications, in two consecutive years, *viz.*, 1498 and 1949. The canes were inoculated in the field in September in both the years with 16-20 days old Red rot culture, a virulent strain, No.244, received from the Head of the Division of Mycology, Indain Agricultural Research Institute, New Delhi and cultured by the Government Mycologist, Agricultural College and Research Institute, Coimbatore. Strain No.244 is a light race and it is used since the virulence tests showed that in general this morphologic group is more virulent than the dark physiologic races. Data were recorded in March 1949 and 1950 when the final observations were taken on the linear spread in inches of Red rot attack, above and below the point of inoculation, the total length of cane, the total number of internodes in the cane and the number affected with Red rot.

In March 1950 ten mature canes in each of the above Co. canes were prepared by cutting each cane into 4-foot pieces and inoculated with the same strain according to the laboratory method and the data were recorded after a month. The result of 1948 and 1949 field inoculations and 1950 laboratory inoculations is given in table 1.

Table 1. Showing the Resistance or Susceptibility of different Varieties of Co. 213 parentage tested in the two years (1948 and 1949) under Field method and in 1950 by the Laboratory method of Red rot infection

(RED ROT)

Variety	Field method		Laboratory method 1950	Variety	Field method		Laboratoy method 1950
	1948	1949			1948	1949	
Co. 213	S	S	S	Co. 377	MS	S	MS
Co. 295	S	MR	R	Co. 384	S	MR	R
Co. 296	MS	MR	MR	Co. 385	—	MR	MS
Co. 297	MR	R	MS	Co. 386	MS	MS	MR
Co. 2096	MR	MR	—	Co. 387	MS	MR	MR
Co. 298	HS	HS	MS	Co. 388	MR	R	MR
Co. 300	MS	S	MS	Co. 450	MS	MR	MR
Co. 31	MS	MR	MR	Co. 451	MS	R	R
Co. 302	R	MR	MR	Co 509	MR	MR	MR
Co. 311	S	MR	R	Co. 510	MS	MR	R
Co. 312	S	S	S	Co. 511	MR	R	R
Co. 313	MR	MR	MR	Co. 512	MR	MS	MS
Co. 320	MS	S	MS	Co. 513	MR	MS	R
Co. 327	HS	HS	HS	Co. 514	MS	MS	HS
Co. 328	MR	MR	MR	Co. 528	HS	MS	MR
Co. 329	—	MR	MR	Co 529	MR	R	R
Co. 330	HS	MR	MS	Co. 530	MR	MR	MR
Co. 331	HS	HS	HS	Co. 531	S	MR	R
Co. 332	MR	R	R	Co. 532	MR	R	R
Co. 338	MR	R	S	Co. 535	S	MR	R
Co. 339	MR	R	MR	Co. 536	S	S	MS
Co. 340	MR	MS	R	Co. 537	HS	HS	MS
Co. 350	MR	MR	R	Co. 538	MS	MR	MR
Co. 370	MS	R	R	Co 556	HS	HS	MS
Co. 371	MR	MS	MR	Co. 562	HS	HS	MS
Co. 372	MR	MR	MR	Co. 680	MS	MS	MR
Co. 373	HS	S	MS	Co. 637	R	HS	MS
Co. 374	HS	MR	R	Co. 660	MS	MR	MR
Co. 375	S	S	—	Co. 661	HS	MS	MR
Co. 376	MS	MR	MR				

R ... Resistant
MR ... Moderately resistant
MS ... Moderately susceptible
S ... Susceptible
HS ... Highly susceptible

Discussion and Results.

(*a*) *The effective lesion length*—It is observed that the mere puncturing of the internode without any inoculum causes reddening

to a length of about 4 inches. So in considering the lesion length, allowance has to be made for the reddening which would be caused in the inoculated internode by the puncture. The effective lesion length, therefore, is got by substracting the length of reddening due to puncturing from the observed lesion length. Comparison of the effective lesion length alone will give a correct idea of the relative resistance or susceptibility of the varieties.

(*b*) *Method of clssification*.—The method usually adopted to classify varieties is based on the ratio with reference to the linear spread of Red rot in the most susceptible variety. Varieties falling within one fourth of the total linear spread as resistant, those from one fourth to half as moderately resistant and from half onwards as susceptible. Suppose the maximum linear spread was 40 inches in a particular year, those showing 0—10% would be resistant. That is allright so far as it goes in a particular year. Suppose the next year among the new varieties there is one which shows a linear spread of 60 inches. Then 60 inches maximum length and not 40 inches will become the criterion for determing the degree of resistance, *i.e.*, 0-15% will be classified as resistant whereas in the previous year a variety showing 15 inches would have been only moderately resistant, with the result that in this particular year, because the maximum length being 60 inches, the same variety with 15 inches becomes resistant.

So it was thought that it would be desirable to have one standard and Co. 213 is quite a good standard and resistance or susceptibility is based in relation to this variety alone. Varieties showing much more linear spread as compared to Co. 213 are classified as highly susceptible. So the effective lesion length was expressed in the three experiments as a percentage of that of Co. 213. The different groups of resistance or susceptibility were made in the following manner.

0	...	Immune (I)
0·1 to 25%	...	Resistant (R)
25·1 to 50%	...	Moderately resistant (MR)
50·1 to 75%	...	Mederately susceptible (MS)
75·1 to 100%	...	Susceptible (S)
Greater than 100%	...	Highly susceptible (HS)

These are, ofcourse, no sharply defined limits between the classes and many varieties fall in the border line. Nevertheless, such a classification is convenient and indicates the relative degree of Red rot injury.

It has been seen that more or less the same agreement is present in the two sets of comparisons. The laboratory and the field methods show more or less fair agreement. Moreover, Co. 213, Co. 299, Co. 312, Co. 331, Co. 373, Co. 556 classed as susceptible to field method have not had their classification changed when tested with the laboratory method. So it appears that the laboratoty method may be used for assessing Red rot resistance of varieties since it shows a good agreement with the field method and also possesses the advantage of being completed in a short time. More conclusive evidence might be obtained if the varieties are tested for a number of years. Of course, the observations must be supplemented by field study to get the true picture of relative varietal performance under plantation conditions.

Evolving Red Rot resistant seedlings—An important aim of the disease testing programme has been the determination of types of seedligs in respect of Red rot infection which different combinations would give in order that greater utilization of parents producing more of resistant varieties might be made in the breeding programme. With this object in view, different crosses arising out of the combinations of resistant and susceptible parents were effected. Such of those seedlings from each of the above crosses that produced sufficient cane to provide a three to four stalk sample for Smut test were taken up at the stage of the transplanting from the first ground nursery to the second ground nursery and the clump of each seedling was divided into three parts in the following manner: The cane formed shoots were cut and separated which formed the first part. These canes were cut into one budded setts and were dipped in Smut spore suspension in water and planted to observe the resistance or otherwise of the variety to Smut. Then the stubble was divided into two equal halves, which constitute the second and the third part. One half was planted separately as control and the other half was planted in another plot and after the canes have made sufficient growth, these were inoculated with Red rot culture and the reaction studied. Simultaneously a few canes from each clump are tried by the laboratory method. Thus, one and the same seedling is tested for Smut and Red rot, both by the field and the laboratory methods and a part of the stubble is planted as control for further propogation if found resistant to Smut and Red rot. The number of seedling that are being tested are large enough to give a fairly reliable indication of the distribution of Red rot resistance in all progenies.

Red rot Varietal Resistance test on Final year test seedlings—In order that the resistance and susceptibility of the hundreds of seedlings tested in the final year plot each year may be determined before they are selected and made into Co. numbers, these seedlings are being tried for their reaction to Red rot by the laboratory method. It may be that by this method we may be able to spot out susceptible varieties as the one year's experience has shown

that varieties classed as susceptible by the laboratory method have also remained susceptible when tried by the Field method. Those seedlings that are otherwise good and possess considerable field resistance to Red rod will be assigned Co. numbers and turned over to the Sugarcane Research Stations in the Indian Union for trial.

Note:—Recently through the courtesy of Dr. E. W. Brandes varieties likely to be use in this work have been imported.

II Smut—Smut is the most easily recognised disease of sugarcane. Affected plants produce from the central spindle long whip like dusty black structures, often several feet in length and much curved on themselves. It is known to occur in almost all the cane growing countries of the world, *viz.*, Java, India, Burma, Philippines Mauritius, Louisiana, Natal, Portugal, Indo-china, Formosa and China. Data on the actual loss of the crop due to this disease is not available. The affected clumps produce only thin, grassy shoots if the infection sets in early. If the infection is late in the season, the weight of smutted cane is found to be appreciably less than that of healthy canes. The varieties most subject to the attack belong to the class of thin indigenous canes, while the attack on the thick canes of the *Pounda* class show distinctly low smut incidence. Systematic roguing and careful selection of the planting material effectively controls the disease. A sure method of controlling the disease is to breed commercial varieties highly resistant to smut. In the varietal trials for smut resistance, Co. 356, Co. 385, Co. 449, Co. 527, Co. 617 and some others have proved fairly resistant to smut. These varieties have been pressed into service in the breeding programme of this station. The seedlings are being studied for their resistance to Smut and also Red rot. The method of inoculation is the same as has been perfected by the Head of the Division of Mycology, Indian Agricultural Research Institute, New Delhi, which consists of dipping one budded sett in Smut spore suspension in water for half an hour, planting the setts either in the field or in pots and watching for the emergence of Smut whips.

III. Mosaic—Mosaic is one of the most widespread of cane diseases and has been reported from every cane growing country. It has been responsible for spectacular epidemics and in some countries there was an astounding decrease in production and the industries were for a time threatened with extinction. Mosaic appears to have been first noticed in Java by Musschenbroek in 1892, though it was called by the name Yellow Stripe-a term which was unfortunately not very appropriate, because mosaic is characterised by mottling and not by stripes. Valuable contributions as to the real nature of mosaic were later made by Wilbrink (1910, 1922), Lyon (1917, 1921) Stevenson (1917) and others. It was in 1919 that Brandes was able successfully to transmit mosaic under controlled conditions and demonstrated

that *Aphis maidis* was the insect vector. As is well known, *Aphis maidis* is an insect which feeds commonly on Maize, Sorghum and various other grasses.

The behaviour of the four species of *Saccharum* to mosaic is now known with a fair amount of definiteness. Many of the recent commercial varieties contain the blood of two or more of the following species of *Saccharum, viz. Saccharum officinarum, Saccharum sinense, Saccharum Barberi* and *Saccharum spontaneum.* As regards the first, all the varieties are susceptible to mosaic. Some are immune and some are susceptible in *S. sinense* group. The North Indian canes (*S. Barberi*) are very susceptible to mosaic, but very little injured by it. Of the four groups, *S. spontaneum* contains several forms which are characterised by complete immunity to mosaic. Excepting the canes of the *Pansahi* group (*S. sinense*), the other types have been crossed extensively and the data on the seedlings in their resistance to mosaic have been well analysed by Dutt and others (1936).

Since mosaic disease is transmitted by insects which visit cane fields from nearby maize or sorghum it is necessary at the first step in the control of the disease to keep the fields and their surroundings free from such crops which serve as breeding grounds for the insect. By selecting healthy material cent percent control can be obtained and if by any chance any diseased stool appears, it must be dug out and destroyed at once.

Various studies show that the hoped-for-development of varieties immune to mosaic has to be viewed with caution. An interesting case in this connection is of Co. 214 which for about 30 years has not been found affected with mosaic in the field and also remained immune to this disease in varietal resistance tests conducted by Sundararaman (1933). In the recent rather severe attack of mosaic at the Sugarcane Breeding Station even this variety suffered due to mosaic disease. The ultimate solution therefore, lies in the breeding of varieties that would be tolerant if not resistant to mosaic disease. Some of the hybrid varieties not only tolerate the disease, but resist infection as well and in the words of Summers (1948) "it became evident that living with the disease is practicable". With this end in view, varieties such as Co. 453, Co. 617, Co. 644 etc. which are not injured much by mosaic, as reported in the Administrative Report of the Government Mycologist, Madras, have been roped in, in the breeding programme of this station. Many of the varieties released from this station are tolerant to this disease. Recently varieties likely to be of use in this work have been imported from U. S. A. through the courtesy of Dr. E. W. Brandes.

Acknowledgements—Grateful acknowledgement is made of the help of Dr. R. S. Vasudeva and B. L. Chona of the Indian Agricultural Research Institute, New Delhi for the courtesy of supplying simple spore cultures of Red rot and also supplying Smut spores and

for actively helping the Mycological Assistant by personal visits to Coimbatore. Special thanks are due to Messrs. D. Murdarajan and T. S. Ramakrishna Iyer of the Agricultural College and Research Institute, Coimbatore, but for whose help the work would not have progressed as there are no facilities at this station for culturing the fungus.

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My. 2—Infection and Development of Ustilago Scitaminea Syd. in Sugarcane

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and

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Reduction in cost of cultivation of sugarcane is assuming inportance in cheapening sugar and in this ratooning of sugarcane is an important practice. With the introduction of Coimbatore canes, ratooning has become an established practice with the cane growers and instances are not lacking where the crop has been ratooned three to four times. In sugar factory areas the factories insist on ratooning once only and in *Gur* areas ratooning twice or thrice is more frequent. With the elimination of Red-rot as a threat to cane cultivation this crop did not face any serious disease on an epidemic form, but Smut is increasing under the *ryots'* conditions and in the case of the Hospet area in Bellary District, the disease had to be controlled by banning ratoons under the Madras Pest and Diseases Control Act. Co. 419, the most popular variety of both factory and the *Gur* areas, is susceptible to this disease. Particularly the incidence is greater in successive ratoons. Though the percentage of incidence is generally recorded, actual loss in tonnage of cane or sugar produced for any particular tract has not been evaluated. Though the seriousness of this disease in being realised the *ryots* have not taken preventive measures to check the same. The soil, air, irrigation water and seed materials

are agencies for the spread of this disease. But the relative importance of the one or the other have not been assessed. As a preliminary step in this direction, studies were undertaken at this station to assess the incidence through different modes of infection and also the course of development of the fungus inside the plant was followed.

Modes of infection—There are two important modes of carry over of the disease, *viz.*, (1) Internal, in which case the mycelium of the fungus or spores are embedded in the tissues of the sett ; (2) external, in which case the spoes are adhering to the sett or may be brought into contact wi th the planted setts through the soil, air or irrigation water. Different modes of infection, as detailed below. were tried to see if the disease could spread through any one of them, The results of observations made on these studies are briefly mentioned here under :—

1. *Internal infection*— The possibilty of the disease being carried over through internal infection was studied by (*a*) Planting setts from shocts which had already thrown Smut whips, (*i.e.*), smutted shoots, (b) planting setts taken from apparently healthly shoots of smutted clumps, (c) by planting setts from apparently healthy shoots from healthy clumps, adjoining or near affected clumps, and (d) by planting stubbles which had thrown out Smut whips in the preceding crop. In all the above studies, Co. 419 the popular variety, was used.

(*a*) *Setts from smutted shoots*—When the growing shoot ends into the Smut whip, the buds in the top portions of canes are not developed or are malformed. Buds in the lower regions of the same cane are apparently healthy. When setts were cut from these apparently healthy portions of the smutted cane and planted, the new shoots threw out Smut whips in their early growth—within a month or two. When such canes were examined under the microscope, mycelium and spores of the fungus were present, down the very bottom of the shoot. Hence, the carry over of this disease in this case is definitely internal and in such cases the emergence of the whip in the germinated bud is quite early, being noted as early as 15 days in some observations.

(*b*) *Setts from apparently healthy shoots of smutted clumps*—The can growers are prone to take healthy shoots as seed material from smutted clumps. Though this department is advising the *ryots* to pull out all smutted clumps, the *ryots* feel the loss of pulling out the healthy clumps. They forget in the process, the danger that lies ahead in utilising such apparently healthy canes as seed material. Even though the crop may appear free of Smut whips at the harvest time there is the danger of the disease lurking in the canes and appearing when setts from these are planted. To examine this aspect, apparently normal canes from smutted clumps were cut and planted and also examined under the microscope for the presence of

the fungus in the tissues. Such examination revealed the presence of mycelium of the fungus in the bottom region of the normal canes and this discloses the possibility of the fungal hyphae traversing from smutted shoots to the other normal apparently healthy shoots of the same clump, the infection being internally direct. When such setts were planted, Smut whips appeared only from such portions which contain the fungal hyphae in them. This definitely reveals the danger of taking seed material from smutted clumps.

(c) *Setts from clumps adjoining the affected ones*—When setts were cut from canes adjoining smut-affected clumps, the disease was not so effectively carried over internally. However, external infection in such cases is not ruled out and studies reported in later sections reveal the possibility of the same.

(d) *Planting of smutted stubbles*—Instead of planting individual shoots after the canes were cut to ground level, the stubbles were uprooted and replanted to test the appearance of the disease. Another lot of the uprooted stubbles was washed with water before planting. Though the disease appeared in both the cases the number of whips from unwashed stubbles was greater, indicating the possibility of soil borne external infection enhancing the incidence.

(2) *External infection*—The two important modes of external infection studied are on soil and planting material.

(*a*) *Soil*—Spores were mixed with soil and setts were planted in this infected soil. Infection was noticed and germinating buds threw out whips in 67 days. In another test, spores were dropped at different distances in the soil from the base of the clump. 3", 6", 9" and 12" were the distances tested and it was noticed that infection was the greatest with the nearness of the spores to the clump. In an earlier section of this paper it was mentioned that washing smutted stubbles and replanting, reduced the incidence of infection. These studies indicate that the soil also can prove an effective source of infection.

(*b*) *Setts*—Spores sticking externally to the seed material may prove an important source of infection and as such this was tested. Infection through cut ends and pricked buds and injured internodes were tested. When cut ends of setts were smeared with spores and planted, infection was found possible, but infection by pricking the buds with spores was most effective. When spores were introduced into the inner tissues of an internode, through a corkborer, the incidence of the disease was found possible. When the spores were introduced into the mature internodes of growing canes through corkborer as mentioned above, infection was not effectively carried. However, when this was tested on tender tissues near the meristem, by introducing the spores through a hypodermic syringe

the disease was noticed in most cases. In a single shoot more than one whip also appeared.

That these tender regions of cane take the disease quite easily was evident from the fact that Smut whips appeared when spore suspensions were poured down the sheath in the tops of canes. But, this was not so effective as when the spores were directly introduced into the tissues. That the tender regions take the disease more easily is also indicated by a greater incidence in setts from top halves of canes than setts from mature portions of cane, when the pin prick method on the bud was the mode of inoculation of the disease. Buds from butt ends of canes below ground level when tested in a similar way, showed greater incidence than the mature buds above the ground.

These studies reveal that the danger of external infection through soil or air is greatest in the tender regions at the top and the older subterranean buds.

The above studies indicate that setts from smutted clumps definitely carry over the pisease to a very large extent through internal infection, while the healthy clumps from a smutted field can carry the disease by external infection in which the tender top regions of cane and older subterranean buds prove more susceptible to infection. Soil may prove an external source when the germinating buds come in immediate contact with the spores. However, the role of soil in this remains to be studied further in respect of viability of the spores when mixed with soil. Studies in this direction are under progress.

Development of fungus in can—The development of fungus in the tissues was studied in the variety Co.475, which is susceptible to this disease. The single budded setts were artificially inoculated by pin prick on the bud. Single budded setts from smutted shoots were also studied. The course of fungal development was similar in both the cases with the difference that the smut whip did not appear even up to 70 days by artificial inoculation while it appeared by the 15th day in the case of smutted setts.

When buds infected by the pin prick method were planted, they germinated and revealed the presence of the fungal hyphae internally. These were examined at intervals. The fungal hyphae largely confined to the lower regions of the growing shoot upto the 30th day, the hyphae were found either coiled or sporulating. After the 30th day their presence was noticed even in the growing points with the difference that there was greater accumulation of spores in the upper regions. Beyond the 40th day piling up of spores in the top was found to be continuous. The same habit of piling of more spores to the top end was noticed when setts from smutted shoots were planted. These studies reveal two interesting points, *viz.*, the multiplication of the fungus in the tissues by (1) repeated sporulation

and (2) piling up of spores in the top regions. This second habit when present in a pronounced form due to any favourable conditions that may exist, seems to be the factor behind the growing point ending in a whip like structure, full of spores. Internally, the hyphae pile up spores and this heap is pushed up from the bottom, until it ends in whip of spores. When the spores are crowded into this heap, the conditions for their germination seem to be unfavourable. This is also indicated by observations under a microscope, where germination of freely floating individual spores is much greater than in the case of aggergates of spores.

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My. 3—Some Studies On Pine Apple Disease Of Sugarcane

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The yield of sugarcane is more influenced by population per acre than by mere elongation of the stalks which means, good stand in the field should be ensured to attain high yields. A casual study of the crop under *ryots'* conditions reveals that in many cases the stand of the crop in the field is poor, mostly due to poor germination of the planted setts. Though the cultivator attempts to fill up gaps by planting fresh setts, the failure in such gap-filling setts in much greater and even when germinated, the shoots from these do not catch up with the main crop. The filling up of the gaps is difficult due to scarcity of irrigation water in most places. Therefore, there is a great need to ensure high germination percentage with the initially planted setts. The failure of germination in planted setts is one of the major causes for low yields recorded under *ryots'* conditions.

The major cause of failure of cane setts to germinate is reported to be due to Pine Apple disease or sett rot in Mauritius, Java, and other places. It is caused by the fungus *CERATOSTOMELLA PARADOXA* de Seynes. The disease was first noted in Java in 1893 by Went. In Hawaii, it was reported by Cobb in 1906, causing the greatest amount of damage in newly planted cuttings. In 1933, it was reported to have been found on standing canes in Coimbatore by Subramanyam. According to Lee (2) Pine Apple disease was widely spread causing great losses, some fields noted having been entirely replanted in philippines. The disease causes serious economic losses, specially under drought conditions and in cooler uplands. It is chiefly sett-borne and is known to attack bananas, coconut and pine apples also.

It was observed at the Sugarcane Research Station, Anakapalli that a number of setts planted in pots as well as in fields, for experimental purposes, failed to germinate, either partially or completely. Such of those setts which failed to germinate were dug out and examined periodically for determining the cause of the failure.

Initial examination of the ungerminated setts showed that the setts were affected by the Pine Apple disease. Further studies were undertaken in order to see how far the fungus is responsible for the failure of germination in the setts in this tract.

45 single buded setts of Co.419 were artificially inoculated with culture of *CERATOSTOMELLA PARADOXA* de Seynes., isolated from infected setts, examined initially by swabbing on the cut end and on the buds and planted in three pots, with 15 setts in each pot. 15 single buded setts with any inoculation were also planted in a fourth pot to serve as control. On the 10th day after planting, untreated setts (control) showed signs of germination, while the inoculated setts did not show any sign of germination. Two buds of the treated setts, however, were found to be swollen and enlarged. 15 days after planting, the setts in the control series germinated normally while there were no signs of any germination in the inoculated series.

It is seen that setts inoculated with Pin Apple fungus completely failed to germinate. Even the two buds which were found swollen and enlarged on the 10th day dried up afterwards. These two buds enlarged in the process of germination before the fungus made headway into the sett, but as the fungus progressed invading the tissues by the 15th day, the enlarged buds also dried up due to the infection of the fungus later. In the control pot, 12 out of 15 setts germinated normally, only 3 setts having failed to germinate due to causes other than sett rot.

The ungerminated setts of the inoculated series were split open and examined. The tissues of the setts were soft and succulent. There was complete disintegration of the cells except the vascular bundles, which remained as distinct threads. The tissues near the cut ends were softer than those in the interior, thus indicating that disintegration progressed from the cut ends towards the interior. Scrapings taken from the internal tissues near the cut ends showed numerous spores of the fungus, while scrapings taken further inrerior showed spores which have not fully developed. These spores were lighter in colour and smaller in size than those near the cut ends. The size of the spores varied from 25u×8u at the cut ends to 7u×5u towards the interior. Further, sporulation was found more profuse at the cut ends than in the interior portions. This is easily noticeable from the intensity of blackening which is more at the cut ends than in the interior.

Some of the inoculated setts were found affected by termites also. Such setts showed perceptibly more sporulation of the fungus and larger area of infection. This is probably due to the facility afforded by the initial termite attack giving more area and space for the fungus to develop and also the insect acting as a carrier of the disease.

All the affected setts emitted a characteristic strong alcoholic smell.

It is further noted from the affected setts, which were in various stages of infection, that the tissues of the sett first turn red. The red colour gradually fades into light yellow which further changes into a dirty white colour. At this stage, the tissues are completely disintegrated. Afterwards the region near cut ends and then the pith region gradually become deep block, with the formation of spores. Examination of coloured and apparently normal tissues that had not fully disintegrated, revealed the presence of mycelium of the fungus. The fungus was reisolated from these coloured and apparently normal tissues.

Thus, within 15 days the fungus invades the tissues of the sett, disintegrates the cells, and retards normal processes which are necessary for the bud to germinate.

Mode of infection—Having found in the initial trials in this tract that the Pine Apple disease can cause total failure of germination another experiment was laid out to study the mode of infection of the fungus.

Four lots of healthy setts of Co.419 were selected, each lot containing 16 single budded setts and treated as follow :—

(1) First lot of setts were inoculated by pricking the scales of buds with a pin dipped in a spore suspension of the fungus.

(2) Second lot was inoculated by swabbing spore suspension on the buds

(3) Third lot was inoculated by swabbing spore suspension on the cut ends

(4) Control (untreated setts)

Each lot was planted in one pot. After 15 days of planting the pots were examined individually and it is evident from that the fungus effectively enters the sett through the cut ends. Quintus (4), Subranyam (6), and Martin (3) also state that infection takes place through cut ends.

Conclusion—Failure of germination under *ryots'* conditions is rather a serious problem, the causes of which have not been investigated in this State. From the above studies it is seen that the Pine Apple disease might prove to be a major cause of failure of setts to germinate, thus causing serious economic losses. Now that disease has been noted to cause total failure on this station, a survey for

the prevalence of the disease in the important cane growing tracts of this State is being planned.

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M. 4—Behaviour of Coimbatore Canes with Respect to Diseases in Hyderabad State

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Introduction—Hyderabad grows more than 60,000 acres of sugarcane, chiefly in the districts of Nizamabad, Bidar, Osmanabad and Medak. Nizamabad, being in the perrenial zone of irrigation under the Nizamsagar Project, is the main sugarcane district. It has got a sugar factory crushing 1200 tons per day, at Bodhan, and another one is also under erection by the side of it.

Hyderabad was previously growing the so called 'desi' (local) varieties of cane. But actually none of the varieties under vogue was local ; they were striped Mauritius canes or 'Pundia' of the Bombay-Deccan. The first Coimbatore varieties to be introduced in Hyderabad were Co. 213 and Co. 290. These had a restricted popularity and were called the 'sarkari' canes. But with the advent of the sugar factory in 1935, Cos. 213, 290, 419 and a few Java canes, POJ 2878 and E. K. 28, were being grown on large areas in the district of Nizamabad. Finally Co. 419 became the most popular cane.

In connection with the agricultural development of the Nizamsagar project Area, the Department of Agriculture, Hyderabad, obtained

a number of promising Coimbatore canes, suitable for the mill, for testing their performance under the Nizamabad conditions. Thus at the Agriculturul Research Station, Rudrur, a Sugarcane Research Section was established and preliminary trials with Coimbatore canes were started. At this time, it was thought desirable to make a study of the behaviour of these canes with respect to the diseases found in Hyderabad.

In Hyderabad, sugarcane chiefly suffers from the attack of only on fungous disease, smut. Striga, the root parasite, is ofcourse very common and sometimes causes a very serious damage to the crop. Red rot, which has been the menace of many a sugarcane plantation in India, is fortunately very negligible. Virus diseases are generally absent, except for some sporadic traces of mosaic and streak. Tangle top is the only other trouble which is rather widely prevalent.

Since 1943, the Coimbatore canes are being studied for their behaviour towards Smut and Striga, at Rudrur (Nizamabad). During the first three years, 32 Coimbatore varieties which were included in the preliminary varietal trials, were studied.

Later the preliminary varietal trials were discontinued, and the observations had to be restricted to only some of the promising varieties which were selected for further tests. Hence during the next years observations were made in special 'eksali' (one year crop, planted in January) and 'adsali' (18 months crop, planted in June) experimental plots. In these experiments six varieties, Cos. 520, 523, 527, 532, 419 and POJ 2878 were used. The lay out was statistically done and each variety was replicated 5 times. In each replication 450 eyebuds, were planted. Thus each variety had a crop raised from 2250 eyebuds, in the experiment. The observations for the occurrence of Smut and Striga were made at fortnightly intervals. As the crop of each variety was raised from an equal number of eyebuds, the total number of smutted plants or the striga plants found in the case of each variety are to be treated as an index of the incidence of the disease. These figures for 3 years are given below :—

I. Adsali Sugarcane-incidence of smut

	Variety	*1947*	*1948*	*1949*
1	Co. 520	—	2	3
2	Co. 523	—	3	—
3	Co. 527	—	4	—
4	Co. 532	78	113	7
5	Co. 419	—	20	—
6	POJ 2878	—	7	—

II. *Eksali sugarcane-incidence of smut.*

	Variety	1947	1948	1949
1	Co. 520	32	74	24
2	Co. 523	42	56	115
3	Co. 527	14	16	77
4	Co. 532	20	31	359
5	Co. 419	24	51	112
6	POJ 2878	7	12	9

In the case of the experimental plot for the observations on the occurrence of striga, the land was uniformly strewn with viable striga seed before the planting of cane.

I. *Adsali sugarcane-incidence of striga.*

	Variety	1947	1948	1949
1	Co. 520	—	98	2983
2	Co. 523	105	1195	5930
3	Co. 527	—	564	5288
4	Co. 532	—	284	5957
5	Co. 419	28	185	6055
6	POJ 2878	—	234	4981

II. *Eksali sugarcane-incidence of striga.*

	Variety	1947	1948	1949
1	Co. 520	7	733	1702
2	Co. 523	42	1986	2743
3	Co. 527	11	1100	2098
4	Co. 532	12	1625	2527
5	Co. 419	—	550	1692
6	POJ 2878	1	180	1557

Incidence of smut—

Among the different varieties kept under observation, Co. 532 was found to be definitely more susceptible to smut and Co. 419 was comparitively less attacked. In general observations outside these experiments, it appeared that the incidence of the disease depends on the presence of the inoculum in the fields. Usually indiscrimate ratooning without any precaution for the removal of the smutted plants is conducive to a constant increase in the incidence of the disease. If smutted plants are not timely eradicated in any particular year, smut becomes more prevalent in the roundabouts during the next year. Among the Coimbatore canes, no marked difference of susceptibility was observed. Some like Cos. 532, 331 and 313 are definitely more susceptible. Coimbatore canes, in general, are also less susceptible than the thick canes of Mysore, like H. M.-320, 645, 651 and 661. POJ 2878 was observed to be more resistant than the Co. canes to smut.

Incidence of striga—It is difficult to make any generalisation about the susceptibility of the Coimbatore canes to striga. It appears that the main factor is the presence of viable seed in the soil. Whenever the cultural operation are not timely and striga is allowed to flower, the incidence of striga is generally increased in the consequent years. None of the different varieties have, however, shown any marked degree of susceptibility or resistance.

Incidence of other diseases—The incidence of red rot is found to be sporadic and very low, but spots on the mid-rib of the leaves caused by *Colletotrichum* sp. are frequently observed. Red rot was never found to have attained an epiphytotic for as happened elsewhere in India. Probably the environmental conditions in Hyderabad are not quite favourable for this disease to develop enormous proportions.

The other common disease which should be rather called a malformation is 'tangle top', is very widely prevalent. The contributing causes of this malady are still obscure, and the actual damage caused by it is also not assessed. Co. 419 is found to be mostly affected by it.

In short the sugarcane diseases found in Hyderabad are only a few and the Coimbatore canes, Co 419 being the most popular and widely grown, have given a satisfactory performance in general and also with respect to the diseases found in Hyderabad. The only common fungous disease, smut, can be easily kept under control by precaution and timely attention. Striga is also easily controllable by an adjustment of cultural operations.

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My. 5—Varietal Resistance to red rot.

Kirti Kar *and* Daya Ram Singh, Shahjahanpur

The mycological problems, introduced by the breeding of improved canes, find a good parallel in the incidence of new diseases in crossbred cattle which resulted from the crossing of the indigenous breeds with the high yielding foreign breeds. Just as the animal geneticist was dismayed to find that the resulting crosses, whose milk yield was much higher than their Indian parents, had nevertheless lost the immunity to diseases possessed by the indigenous cattle, the sugarcane workers had to face similarly the problem of susceptibility of hybrid canes to mycological diseases. The main drawback with the indigenous canes had been their low-yielding capacity ; but the high yielding, improved ones brought with them new and multifarious agronomical, mycological and entomological problems, all of which

had to be tackled successfully in order to secure the benefit of their yield potential. The mutual exclusiveness of yield and immunity to diseases is explained by the recent researches on the position of genes in the chromosome, which ultimately controls the correlation of characters.

Red rot is the most important disease of sugarcane in the Uttar Pradesh. To gauge the importance of this disease we should take into consideration the following words of a well known mycologist, Bulter (1918) ' Red rot is the greatest obstacle in successful cultivation of sugarcane, a sixth of whose global acreage is grown in the United Provinces'.

The disastrous possibilities of Red rot were truly brought home to the province by the epidemic of 1939 which completely devasted the universally popular Co. 213. Systematic attempts have since then been made to study the causes of malady and its cures. Increasingly greater reliance has been placed on the resistant varieties, as it calls for the least effort on the part of the grower and yields quick results.

The process of evolving resistant varieties is a lengthy one and involves the study of a very large number of seedings in the initial stages followed up by an intensive field study of the promising ones, before any variety can be released for cultivation. In the following paragraphs a brief description of the important methods adopted for these studies has been given.

In order to test the resistance or susceptibility of thousands of seedlings produced each year before they are subjected to further agronomical, physiological, chemical and entomological studies, it is necessary to devise some method which may enable us to test a large number of varieties in much less time than occupied by field trials in which only a limited number of varieties can be handled and a complete growing season is required before any data are obtained. In depending on field tests alone, the varieties are often rejected after considerable energy has been spent in studying their agronomic potentialities.

The above objective is met by laboratory tests which require much less time. The laboratory method adopted by Abbot consists of determining the spread of the Red rot fungus in inoculated cuttings of mature stalks of cane under conditions favourable for the development of the disease, as compared with that in the similarity treated cuttings of standard varieties, the reaction of which in the field and laboratory is known. The stalks of cane prepared by removing the sheaths and tops and cutting into four lengths. Holes are punched into the centre of the two internodes of each cutting, leaving at least one, where possible two internodos, between those punched. With a sterile instrument a piece of a 15-20 day old culture of *Colleto-trichum* on oatmeal agar is introduced. The inoculated setts are tied

in bundles of ten each and incubated in saw dust for 20-30 days at a temperature of 25-30° after which they are split length wise and the spread of Red rot is measured. The alternative method of infecting the stalks consists of smearing the nodes with oatmeal agar. It is being adopted with necessary modifications at Shahjahanpur. The laboratory method of study can be usefully employed, but before adopting it as a criterion for rejecting susceptible varieties a thorough study should be made regarding the extent to which the results obtained in the laboratory are borne out by field tests.

Another method which is being tried at this Research Station for quick tests is "Indian Ink" method which consists of the study of movement of ink particles in the sugarcane plant, when the top portion of the plant has its basal part dipped in a suspension of "India ink". Suspension of India ink is kept in a beaker. The top portions of the canes of the varieties are removed from the plant and so kept that their basal parts remain dipped in this suspension. After one or two days, the movement of particles in the plant is studied. This method rests on the fact that the lumen of the xylem is easily accessible both to the ink particles and spores and the septa of the nodal plate, are considered to be limiting factors in case of resistant varieties. While explaining the probable cause of variation in resistance to Red rot in sugarcane, Edgerton and Carvajal have pointed out that 'Spores of the fungus are able to migrate very rapidly in the ducts of fibre-vascular bundles of certain varieties and with difficulties in others'. This was due to the fact that most of the ducts of the latter varieties are not open at the nodes. The results obtained by this method are, however, not always in conformity with those obtained in field trials.

The ultimate release of varieties for cultivators depends on their performance in field trials for Red rot-resistance. Our studies have mainly been centred round field trails of varieties which have proved promising. The method followed at this Station and elsewhere consists of infecting canes by punchd holes in the month of September and studying the spread of fungus in the following January. The canes are classified for their susceptibility according to the length of the lesions. The following classes have been recognised.

Class I—Resistant—The length of lesion is below 30 cm.

Class II—Moderately susceptible—The length of lesion is 30-50 cm.

Class III—Highly susceptible—The length of lesion is above 50 cm.

Sometimes the results obtained in different years and different Stations show such a range of variation that it is difficult to put a variety in any particular class and consequently approve or reject it for cultivation. The actual range of variation in the performance of different varieties in different years at Gorakhpur and Shahjahanpur will be clear from the data given below :—

Analysis of results from 1942-48

Shahjahanpur

A. Varieties which fluctuated between I & III (1942-48)

Co. K. 26, Co. 527, Co. 557, Co. S. 293, Co. S. 302, Co. S. 303, Co. S. 307, Co. S. 254 and Co. S. 309.

B. Varieties which fluctuated between II & III

Co. 213, Co. 331, Co. S. 545, Co. S. 245, Co. S. 321, Co. S. 146, and Co. S. 76.

C. Varieties which fluctuated between I & II

Co. S. 222, Co. K. 30.

D. Varieties which do not show any fluctuations in their class of resistance.

(*i*) *Susceptible*—Co. 331, Co. 312.

(*ii*) *Moderately susceptible*—Co. 290.

(*iii*) *Resistant*—Co. 453, Co. S. 186, Co 385.

Gorakhpur.

A. Varieties which fluctuated between classes I & III

Co. K. 26, Co. 527, Co. 552

B. Varieties which fluctuated between classes II & III

Co. 527.

C. Varieties which fluctuated between I & II

Co. 331, Co. 395, Co. S. 109, Co. 453, Co. 393, Co. 370, Co. S. 242, P. O. J. 2878, Co. 513, Co. S. 307

D. Variety which does not fluctuate.

Susceptible—Co. 213.

It had been felt from time to time that the 'plug' method provides conditions to the fungus which are at a great variance with those prevalent in nature, as in the process of entry into the host it is not required to meet any of the natural barriers like the sugarcane rind. This provides a chance of varieties possessing commercial-resistance being rejected. To meet this eventuality an experiment was started in 1948 to test the varieties under conditions bearing some proximity to natural conditions. Infection was provided by the following methods :—

1. Red rot debris was applied to the soil before sowing
2. Red rot spores were applied through irrigation water

The effect of above mentioned treatment was tried individually as well as collectively.

The results during the very first year have indicated that the apprehensions about the 'plug' method of testing were not altogether unfounded. Co. S. 245 which is an outstanding variety, and had been found susceptible in tests by the 'plug' method was found safe for cultivation in Western U. P. by this method. This method allows the natural barriers against the Red rot fungus to play their part in resisting the entry of the parasite into sugarcane. It is, however, too early to express any definite opinion about this method beyond the factthat the results are likely to be of value in areas where the disease does not exist in an epidemic form. For areas where the diseases appear in an epidemic form only such varieties should be released which are found resistant by test with the 'plug' method.

The procedure adopted by Abbot for testing advanced agronomic selections is different in several respects. 100-eye bundles are inoculated and planted in mixed or heavy soil to favour Red rot. In one lot the inoculum is introduced into the holes punched into the stalks and in another lot the nodes are smeared. The spread of the fungus is studied after about four months and the varieties are classified according to their resistance. The definition of the classes is as follows :—

Class I—Resistant to nodal infection and to spread in tissues
Class II—Moderately resistant to spread in the tissues resistant to nodal infection
Class III—Susceptible to spread in the tissues, but characterised by temporary check of the fungus at the nodes ; resistant to nodal infection under most conditions
Class IV—Very susceptible to spread in the tissues, with little or no checking of the fungus at the nodes ; resistant to nodal infection under most conditions
Class V—Very susceptible to spread in the tissues and to nodal infection

The agronomic selections which prove resistant in these tests are tested against 5-10 isolates of both races of *Colletotrichum* before being released for cultivation.

The resistant varieties evolved by the above mentioned methods have gone a long way in meeting Red rot menace, but unfortunately it is not yet sufficiently realised that the release of new varieties is only one step in the ladder of higher production. In order to exploit the potential capacity of improved verieties, the cultivator will have to give much greater care to the improved canes than that required by the *desi* varieties which are highly resistants to Red rot. It has been observed that highly resistants varieties when continuously grown under unfavourable conditions have become susceptile to Red rot. It was on account of careless cultivation that extermely useful varieties like Co. 213, Co. 331 aud Co. 312 deteriorated and had to be given up. These varieties fell prey te Red rot, although it is not uncommn to find careful cultivators growing impressive crops of Co.312 and Co. 331 even now.

The emphasis laid by famous Russian scientists, Lysenko and Michurin, on the effects of environments indicate the importance of culturul methods in cane cultivation. The fact that sugarcane is a vegetatively propogated crop also increases the importance of cultural methods, which very largely determine the environments of the crop.

It has been observed that ill drained and uncared for fields, which harbour the diseases, serve as the foci of infection. They are responsible for tha spread of diseases to healthy crops, when a variety is subjected to adverse conditions year after year, it becomes susceptible and the valuable energy and time spent in evolving it is lost.

It is a matter of utmost concern that the cultivator is depending on resistant varieties alone to meet the menace of Red rot. The

loss of varietal-resistance through careless cultivation and the quest of new ones provides an endless vicious circle.

The appearance of new strains from time to time makes the problem of varietal resistance complicated. The varieties which prove highly resistant at one time succumb to the disease when new strains virulent to the variety appear. Such instances are not confined to this country only. To quote a very recent example, the appearance of Red rot on Co. 453 in certain parts of Eastern U.P. and Bihar this year will be very illustrative. Co. 453 which proved to be a resistant cane even in the epidemic year of 1939-40 has been a victim of Red rot in parts of Eastern U. P. and Bihar this year ; although in a much larger area it continues to be the outstanding cane. A study of the strain found attacking Co. 453 has revealed that its behaviour towards different varieties is markedly different from the existing strains. It is particularly virulent towards Co. 453, while the effect on Co. 331 is milder than that on other strains. The lighter strains are usually more virulent than the dark ones, but in case of some varieties the darker ones are more virulent.

On account of the variations in the predominance of different strains, the resistance of different varieties is variable at different periods. When a strain virulent to particular variety ceases to predominate, it will change its class from susceptible to resistant Thus the prevailing flora of the parasite (*Colletotrichum falcatum*) is a very important factor in determining the resistance of different varieties to Red rot.

My.6—Sources and Modes of Red Rot Infection

My.7—Strains of Sugarcanfe Mosaic Virus

B. L. Chona, New Delhi

These two papers were not received uptil 31.12.50. Abstracts of the papers are, however, given in part I of the Proceedings of this Conference.

Printed by L. Harnam Dass Saggar at the Bengal Press, Pull Bangash, Delhi from Pages 1 to 72 and Published by the Indian Central Sugarcane Committee, New Delhi.

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